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List of Abbreviations

ARCH	Autoregressive Conditionally Heteroscedasticity
ART	Alternative Risk Transfer
BCBS	Basel Committee on Banking Supervision
CAT	Catastrophe (bonds)
CEIOPS	Committee of European Insurance and Occupational Pensions Supervisors
CDO	Collateralized Debt Obligations
CDS	Credit Default Swaps
DS	Datastream
EBA	European Banking Authority
EC	European Commission
ECB	European Central Bank
EIOPA	European Insurance and Occupational Pensions Authority
ESRB	European Systemic Risk Board
FSB	Financial Stability Board
GARCH	Generalized Autoregressive Conditional Heteroscedasticity
GICS	Global Industry Classification Standard
GSIB	Global Systemically Important Bank
GSII	Global Systemically Important Insurer
IMF	International Monetary Fund
IAIS	International Association of Insurance Supervisors
SPV	Special Purpose Vehicle
P&C	Property and Casualty
WRDS	Wharton Research Data Services
VAR	Vector Autoregressive (model)

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1 Introduction

The word “domino effect” is often used to describe systemic risk in a financial system. The fall of one firm causes the fall of many others. During the financial crisis of 2008, mainly banks were considered as dominos that could trigger severe chain effects and that have to be prevented from falling by governments. Recently, it seems that there is another kind of domino that has to be considered. Several studies show that the insurance sector is increasingly linked to the banking sector (Billio et al. 2012, Chen et al. 2014, Baluch, Mutenga & Parsons 2011). This means that a shock is not only transmitted from banks to banks but that insurers too might fall due to a bank domino. Moreover, an insurer could itself cause knock-on effects to the banking sector.

This raises the question where the increased interconnectedness of the two sectors comes from. Traditionally, the distinctions between banks and insurers seemed straight forward. On the one hand, banks take deposits and provide credit to the real economy. On the other hand, insurers protect against risk by pooling and diversifying many risks. In addition, insurers act as a long-term investor of the economy. Interlinkages between the two sectors should not be substantial. Nevertheless, recent developments in financial sectors seem to favor increased connectedness. In Europe, financial markets are increasingly integrated and financial conglomerates play an important role. Moreover, insurers have expanded their businesses to new activities, which often resemble traditional banking activities. These developments could favor spillovers between the banking and insurance sector through direct and indirect channels. For example, information spillovers might become more likely if investors can no longer clearly distinguish between banks and insurers.

In a recent report, the IMF (2016) finds that systemic risk in the insurance sector is increasing. Increased interlinkage between banks and insurers could have important implications for systemic risk. A higher interconnectedness of the financial system means that shocks are spread more widely. It seems therefore important to analyze the reasons for the increased interconnectedness of the insurance sector. This thesis focuses exclusively on linkages between insurers and the banking sector. Moreover, only the European financial sector is covered by the analysis. Recent developments in European banking and insurance regulation make the investigation of interlinkages between banks and insurers important. For insurers, Solvency II is effective since 2016 and the Basel framework for banks is still developed further. If links between the two sectors are not considered when regulation is developed, the

combined effect of both regulation might lead to unintended consequences (Al-Darwish et al. 2011). Finally, insurers are long-term investors. As banks are cutting back their financing activity due to stricter regulation after the financial crisis, insurers could increase their importance for financing the economy. Risk spillovers from the banking sector could undermine the insurance sector's role as a potential substitute that is more stable than the banking sector.

This thesis applies a measure of connectedness that is based on Granger causality and was developed by Billio et al. (2012). The measure uses stock returns of banks and insurers. It is investigated whether stock movements of both sectors influence each other. A sample of 30 European banks and 30 insurers is selected to conduct the analysis. For each insurer linkages to the banking sector are analyzed. Next, it is tested which characteristics distinguish insurers that have a higher number of linkages to the banking sector than others. The aim is to find out which developments can explain increased spillovers between the banking and insurance sector.

The thesis is structured as follows. First, the theoretical background is presented. *Section 2* looks at similarities and differences of banks and insurers and presents the European insurance sector. *Section 3* is dedicated to the insurance sector during the financial crisis and the implications for systemic risk in this sector. *Section 4* analyzes how risk can spread between banks and insurers. Next, the empirical analysis is presented. *Section 5* introduces the measure of Billio et al. (2012) and the data. *Section 6* presents the empirical findings on the development of interconnections between the banking and insurance sector. In addition, it is analyzed whether specific characteristics can explain a stronger connection to the banking sector. Finally, *Section 7* points out limitations of the empirical analysis and *Section 8* contains concluding remarks.

2 The insurance sector

2.1 Characteristics of insurers

Before analyzing connections between the insurance and the banking sector, it is important to point out what distinguishes the two types of financial intermediaries. If insurers and banks were alike, connections between the two sectors would not be surprising. Therefore, this section first presents characteristics of insurers and second, similarities and differences to the banking sector are investigated.

The main function of the insurance sector is to protect against risks. There are different types of insurers: Life and non-life insurers. “Non-life” or “Property and Casualty” (P&C) insurers provide insurance against events such as fire, car accidents or natural disasters. On the other hand, life insurers insure against mortality or inability to work due to illness. Some life insurance products have characteristics that make them similar to deposits due to their saving function. Another type are reinsurers, which insure insurance companies. Such insurers take over risks from primary insurers and enable them to smooth premium income. Although basic insurance principles are also applicable for reinsurers, one important difference is that reinsurers only provide services to other businesses and not to households like primary insurers (Das, Davies and Podpiera 2003; IAIS 2011).

An insurance company can provide protection against risks because of risk pooling. A single person might fear idiosyncratic risks such as being hit by car accident or occupational disability. However, an insurer is able to take on a high number of those risks. Only a small proportion of the clients of the insurer is likely to suffer from an adverse event. Therefore, the insurance company can demand a small premium from all of its clients, which enables it to reimburse the small number of clients that is hit by such an event. Risk pooling enables the insurer to diversify idiosyncratic risks (ESRB 2015).

Premiums are invested in assets that, normally, have the same maturity as the claims of its clients. Insurance companies are able to hold assets to maturity. Matching the duration of assets and liabilities is an important function of insurers. Insurers use statistical techniques to predict the probability of claims in order to determine accurate insurance premiums. This is a crucial function for the insurer because it faces technical risks such as underpricing or unforeseen events which could lead to solvency problems (Das, Davies and Podpiera 2003). It should be noted that most of the risks an insurer faces are normally not correlated with

financial markets. An exception are risks related to credit insurance, trade insurance and financial guarantees that naturally depend on the business cycle (IAIS 2011).

The traditional balance sheet of an insurer reflects this model. On their liability side insurers hold reserves for future claims and benefits. The premiums paid by the clients of the insurer are invested in assets. Traditionally, bonds, equities and loans are found on the asset side of an insurer's balance sheet (IMF 2016). The largest proportion of insurers' income is derived from premiums followed by investment income. Premiums provide a steady inflow of funds while outflows are conditional on certain events (Al-Darwish et al. 2011, IAIS 2011).

Some of these features make insurers similar to banks. This is especially true for life insurers. First, both act as financial intermediaries. Life insurers in many countries engage in long-term saving products, which could, for example, provide a retirement income. Therefore, they enable people to smooth consumption similar to banks (Tower and Impavido 2009). Additionally, banks and insurers are important investors for the real economy as they channel private savings into the real economy. Insurers do not provide direct loans like banks, but they buy assets such as bonds or equities on financial markets (Freixas and Rochet 2008, Thimann 2014).

However, in contrast to the insurance sector, the basic functions of the banking system include offering payment services and maturity transformation. Banks collect short-term deposits and make long-term loans. They also rely on other forms of short-term funding such as issuing commercial paper, interbank lending or securities repurchase transactions (repos). This is contrary to insurers that are financed long-term by policyholder premiums. Moreover, the profit of a bank depends on the gap between the return on long-term assets and costs of short-term liabilities (Al-Darwish et al. 2011). This implies that liquidity risk is high in the banking sector. If many depositors demand their short-term deposits at the same time, a bank might not be able to liquidate long-term assets and to pay back its depositors. Therefore, maturity transformation is major source of the fragility of the banking system (Diamond and Dybvig 1983, Freixas and Rochet 2008). In contrast to this, insurers are funded long-term. Traditional insurers are able to match the duration of their assets and liabilities, which makes insurance runs unlikely. In addition, insurers are not part of the payment system. Next, the banking sector is highly interlinked. In the banking sector, there is an incentive to lend to each other if one bank has excessive liquidity while another bank faces high number of depositors demanding liquidity (Allen and Galle 2000). While banks are linked to each other through interbank exposures, no similar links exist between insurers. Some authors argue that the insurance sector is inter-linked because of reinsurance. However, studies do not find increased

vulnerability of the insurance sector in the case of a reinsurer's failure. Primary insurers diversify their exposure to reinsurers. The hierarchical market structure between primary insurers and reinsurers makes feedback loops less likely than in the banking sector (Eling and Pankoke 2014, IAIS 2011). Finally, the role of capital differs. Capital has a stabilizing function for the banking system. The more borrowed money is used to finance investments the more difficulties a bank will experience in time of crisis, when returns might not be enough to pay back creditors. However, in the insurance sector liabilities are made up by policyholder reserves. If an insurer is hit by a shock, assets can be wound down because it is funded mainly by long-term liabilities. Capital ensures that the last policyholder is paid (Thimann 2014). To sum up, traditional features of the insurance sector should make insurers more stable than the banking sector.

Although traditionally the distinction between the insurance sector and the banking sector was very clear, recently, many authors have argued that insurers have started engaging in banking-like activities that blurred the lines between banking and insurance business. Such products are summarized under the term “non-core” or “non-traditional non-insurance activities”. They are characterized by the absence of traditional characteristics of insurance business models that were outlined above (Cummins and Weiss 2013, IAIS 2011). As such products miss characteristics that make the insurance sector more stable than the banking sectors, they seem to have the potential to increase risk in the insurance sector. Acharya and Richardson (2014) point out that modern insurance products involve non-diversifiable risks and make bank runs possible. An example are annuities offered by life insurers that are unit-linked contracts. This means the return of the customer is linked to specific funds that are chosen by the customer. Annuities involve a guaranteed minimum return. This makes the insurer dependent on market developments because difficulties arise if the return of the assets is lower than the guaranteed return or if there is a lack of fixed income assets (IAIS 2016). Moreover, some annuities resemble withdrawable investment accounts (Acharya and Richardson 2014, Cummins and Weiss 2013). In addition, some insurers have started engaging in bank-like activities such as securities lending, which Acharya and Richardson (2014) identify as a form of shadow banking. It should be noted that it is often difficult to determine what a non-core product is. This is illustrated by IAIS (2016a) that stopped using the label “non-traditional non-insurance” for such products and started to focus on certain product features instead that make an insurer dependent on market developments and could undermine its liquidity position.

To sum up, traditional insurers could be clearly distinguished from banks but new activities of insurers make this distinction more difficult. Insurance failures reflect these findings. In the

U.S., mispricing and inadequate loss provisioning were the most common causes for insurers' failures both in the life and in the non-life sector. Another common reason was rapid growth coupled with mismanagement (IAIS 2011). This highlights the importance of technical risk in the insurance sector in contrast to other risks. However, Das, Davies and Podpiera (2003) point out that many recent failures of life insurers involved insurance companies that engaged in bank-like activities or had strong ties to the banking sector.

2.2 European insurance sector

Looking closer at the global and European insurance sector illustrates some of the typical features of insurers outlined above. With regard to insurance market structure, life insurers account for more than half of global insurance premiums, which amounted to 4.1 trillion USD in 2009. 40% were made up by non-life insurers and less than 10% by the reinsurance sector (IAIS 2011). On a European level, data is available from the industry representative Insurance Europe (2016). In 2014, total insurance premiums in Europe amounted to nearly 1.2 trillion euro. Also on a European level, more than half of premiums are accounted for by life insurers. IAIS (2011) concludes that market concentration in the insurance sector is low although it is slightly higher in the life than in the non-life sector. On average, the European insurance sector is growing (EIOPA 2016).

The size of the insurance sector is also important regarding their role as institutional investor. Globally, insurers hold approximately 12 % of financial assets. Most of the assets are held by life insurers (IMF 2016). On a European level, the investment portfolio of insurers amounted to 9.5 trillion euro in 2014, which is about 62% of European GDP (Insurance Europe 2016). Both European life and non-life insurers invest the largest proportion of their portfolio into sovereigns followed by bonds of financial companies and corporate bonds. In general, loans do not represent an important investment category for insurers (EIOPA 2016). Although the size of the European insurance sector is impressive, the banking sector is considerably larger. According to EBA (2015), total assets of the EU banking sector amounted to over 23.5 trillion euros in June 2015. It should be noted that this number excludes Switzerland. Only eight insurers are among the world's 50 largest financial institutions; the three largest are AXA, Allianz and MetLife (IAIS 2011).

European insurers are also engaged in non-core activities. However, the European Systemic Risk Board (2015) concludes that on the liability side of insurers' balance sheets, activities such as annuities with guarantees only amount to 4% of technical provisions that represent obligations to policyholders. Nevertheless, it is noted that those activities might be much more

important on the asset side. Moreover, while annuity contracts have been common in the U.S. and Japan since the 1990s, their popularity has only recently started to increase in Europe (EIOPA 2011, Geneva Association 2013). With regard to bank-like activities, securities lending seems to be most important. The sale of credit default swaps does not seem to be an important activity for European insurers, which could partly be attributed to restrictive EU insurance regulation. In particular, banks buy only 1% of their holdings of CDS from insurers (ECB 2009). However, the Swiss insurer Swiss Re suffered huge losses in 2007 due to underwriting of CDS (IAIS 2011). Thus, despite low aggregate exposure, there could be high concentration of CDS sales within one firm.

2.3 European regulation of insurers and banks

As traditional insurers and banks seem to be different in many aspects, it is not surprising that supervision and regulation of banks and insurers is separated. Nevertheless, regulation of both sectors should not be regarded as independently from each other.

At a European level, the European Insurance and Occupational Pensions Authority (EIOPA) is responsible for the supervision of insurance companies while the European Banking Authority (EBA) covers the banking sector. The tasks of the authorities include ensuring consistency of regulations within the European Union and support the stability of the financial system. Both authorities work together in the Joint Committee of the European Supervisory Authorities. One task of this committee is to ensure coordination regarding financial conglomerates. The European authorities assess cross sector implications of firms that are active in the banking as well as in the insurance sector. Moreover, since November 2014 the European Central Bank supervises significant European banks (European Parliament 2016, EBA 2016).

Regarding the regulation of the two sectors, European rules differ in their development and content. In 2016, the Solvency II regulation came into force for EU insurers. Solvency II was developed on a European level. Although the European Commission already adopted the new regulation in 2007, it took almost 10 years until it came into force. Solvency II aims to harmonize EU regulation on insurers and introduces risk-based capital requirements for the insurance sector. The aims are to promote good risk management and to ensure that capital is adequate to an insurer's risk (European Commission 2015). In the banking sector, Basel III came into force in 2013. It was a reaction to the financial crisis and one of its aims is to increase the quality and quantity of capital to make the banking sector more stable. Basel III was intended to fix shortcomings of Basel II that became apparent during the crisis. In contrast to Solvency

II, Basel is a global accord developed by the Basel Committee on Banking Supervision (BCBS). Those international standards are implemented by EU legislation (Al-Darwish et al. 2011). With regard to financial conglomerates, the Financial Conglomerates Directive (FICOD) was implemented in 2002 and sets out additional rules to avoid multiple use of capital and to address group risks (European Commission 2010).

At first sight, the Basel framework and Solvency seem to have some similarities. Both regulations have a three pillar structure. The pillars refer to quantitative capital requirements, supervisory approach and market discipline. Moreover, both accords suggest a risk based approach to determine the adequate level of capital and both promote the use of internal models (Al-Darwish et al. 2011).

However, comparing the details of both regulations reveals that they differ in many aspects. In some cases, insurers and banks will have to hold different amounts of capital for the same risk (Laas and Siegel 2015). There are several reasons for differences of the two accords. Al-Darwish et al. (2011) point out their aims only partially overlap because Solvency II does not necessarily want to increase the overall level of capital. Moreover, differences can partly be attributed to fundamental differences of the banking and the insurance sector. Finally, both regulations had independent development processes. This could explain differences that are not due to different characteristics of the two industries.

Differences could lead to unintended consequences of the two regulations. As banks and insurers have, at least partly, similar investment portfolios, regulatory arbitrage is possible. It is likely that regulation will influence demand of banks and insurers for different asset classes if different types face different capital charges. Especially, conglomerates that are active in both sectors could be incentivized to shift investment classes between banking and insurance units to reduce their capital charges (Laas and Siegel 2015). Moreover, both regulations could increase the incentives for risk transfer. Both banks and insurers could aim to lower capital charges by moving risks off their balance sheets through securitization or reinsurance (Al-Darwish et al. 2011). Another consequence could be increasing demand for sovereign debt. Under Solvency II, insurers using the standard approach do not face any capital charges for EU sovereign debt (Düll, König and Ohls 2015). Similarly, the European implementation of Basel III de facto allows banks to apply zero risk weights to sovereign debt although the Basel accord would in principle foresee positive risk weights. The application of zero risk weights to EU sovereign bonds is criticized as it may lead to too low capital charges and to overinvestment in government bonds (Lenarčič, Mevis and Siklós 2016). Solvency II might

lead to similar risks in the insurance sector and increase the demand for EU sovereign bonds further.

The developments of the two regulations could have interesting implications for European loan markets. Basel III forces banks to increase their capital bases. It seems likely that banks will reduce lending to deleverage. This raises the question which alternative sources could provide loans to the economy. One possibility are institutional investors such as insurers. They might be able fill the bank-shaped hole left by shrinking European banks due to their ability to invest long-term (The Economist 2012). However, Solvency II makes the holding of long-term loans relatively unattractive for insurers (Wehinger 2012). On the other hand, the European Commission seems to be aware of such concerns and will take measures to encourage long-term investments by insurers (European Commission 2014). For example, infrastructure investments by insurers should be increased by preferential capital treatment of such investments (European Commission 2016a). There seems to be the potential for insurers to move further into fields and take over risks that were traditionally borne by the banking sector. Currently, loans to households and to finance infrastructure make up a very small proportion of insurers' balance sheets (ESRB 2015, European Commission 2016a). It is not clear yet what will be the combined effect of new banking and insurance regulation on the European credit markets.

It remains to be seen how the implementation of Solvency II and Basel III will influence European banks and insurers. This section has shown that it is important to consider cross-sector implications when developing banking and insurance regulation.

3 Systemic risk in the insurance sector

3.1 The insurance sector and the financial crisis of 2008

Linkages between the banking and the insurance sector became apparent during the financial crisis of 2008. The crisis is considered a “banking crisis” because one underlying reason for the crisis was the change of banks’ business model. Many banks were involved in the securitization of mortgages of U.S. banks. Moreover, banks relied more and more on wholesale funding, which made them dependent on short-term market liquidity. European banks developed similarly. Regulation also played an important role as it did not prevent insufficient capital buffers and regulatory arbitrage (Blundell-Wignall, Atkinson, and Lee 2008). Those developments made banks vulnerable to a financial crisis. After a downturn in the housing market and the collapse of Lehman Brothers in 2008, banks’ assets suffered huge losses and banks experienced funding difficulties (Shleifer and Vishny 2011). Finally, governments intervened to save banks that were hit by the crisis.

The characteristics of traditional insurers, which were outlined in *Section 2.1.*, are supposed to make the insurance sector more stable than the banking sector. Especially in case of crisis, the insurance sector could have a stabilizing function due to its long-term funding by premiums and its ability to hold assets to maturity. Insurers partly seem to have had a stabilizing function during the financial crisis of 2008. Generally, the balance sheets of insurers were only temporarily affected by falling asset prices, and they continued to provide insurance services, which corresponds to the traditional definition of insurance. The solvency of most insurers was not endangered (Schich 2010, IAIS 2011). Nevertheless, one case that has led to increased attention to risk in the insurance sector was the bail out of the U.S. insurer AIG by the U.S. government after the failure of Lehman Brothers. AIG was linked to Lehman Brothers through credit insurance by CDS contracts. Similarly, the European insurer Swiss Re suffered losses due to its involvement in the CDS market. A CDS insures against the default of an underlying asset, but if many defaults occur at the same time, claims can exceed inflows, which happened during the financial crisis. To sum up, while traditional insurers were not harmed severely, some parts of the insurance sector that engaged in so-called non-traditional activities were hit by the crisis and even contributed to downward trends in financial markets (Baluch, Mutenga, & Parsons 2011, Schich 2010).

With regard to the performance of insurers’ shares during the crisis, it seems that life insurers and EU insurers except the UK were among the worst performing group. One explanation for

the difference between UK and non-UK firms could be the strong relevance of financial conglomerates within the EU. Possible explanations for the superior performance of life insurers could be different investment strategies as life insurers invest relatively more in equities. Moreover, there seem to be stronger engagement of life insurers in no-traditional insurance activities (Baluch, Mutenga & Parsons 2011, IAIS 2011).

Although the crisis is considered a “banking crisis”, it hit insurers too. This lead researchers and regulators to reconsider stability of the insurance sector and to consider systemic risk in this sector.

3.2 Definition of systemic risk

Before describing systemic risk in the insurance sector, it has to be defined what is meant by “systemic” risk. There does not seem to be a unique definition of the term systemic risk. One definition is proposed by the IMF, FSB and BIS (2009), which define systemic risk “as a risk of disruption to financial services that is caused by an impairment of all or parts of the financial system and has the potential to have serious negative consequences for the real economy” (IMF, FSB and BIS 2009, p. 2). Following Kaufmann (2000), definitions of systemic risk include two important elements: a sudden shock that hits the financial system and potential spillovers that lead further transmission of the shock. A shock could be a sudden fall of the price of banks’ assets, which would weaken them and could disrupt the provision of credit. Moreover, the definition provided by IMF, FSB and BIS (2009) emphasizes the risk of a failure of one part of the financial system that leads to disturbance of other parts. The risk of a shock that is not further transmitted within financial markets is not considered systemic risk. Transmission channels will be discussed in more detail in *Section 4*. This definition fits the financial crisis of 2008 as there was a shock originated in the housing market and that was spread to banks and also, to a lesser extent, to insurers (See *Section 3.1*).

Baluch, Mutenga and Parsons (2011) emphasize the difference between “micro” and “macro” systemic risk definitions. In the first case, the failure of a single institution causes a chain reaction that hits the wider financial system. In order to identify such systemic important institutions, the IMF, FSB and BIS (2009) suggest three main criteria: size, lack of substitutability and interconnectedness. In the case of macro systemic risk, a shock hits many participants at the same time because they have common market exposures. A crisis cannot only be triggered by the failure of one systemically important institution but also by the failure of some large or many small firms that represent a significant part of the financial system (Acharya and Richardson 2014, IMF 2016).

Traditionally, primarily banks were seen as potential sources of systemic risk. However, recently some authors discussed whether insurers could, at least in theory, pose systemic risk too. With regard to the “macro” view of systemic risk, insurers should be less risky than banks as they are normally able to diversify risks and large common exposures are thus unlikely. However, as pointed out in *Section 2.1* modern insurance products might involve non-diversifiable risks that could make insurers vulnerable to common shocks (Acharya and Richardson 2014, IMF 2016).

With regard to micro systemic risk, Cummins and Weiss (2013) analyze whether the criteria size, lack of substitutability and interconnectedness can be applied to insurers. First, regarding size, Cummins and Weiss (2013) write that this criterion does not really seem important in an insurance context. The insurance business is characterized by the possibility of an orderly insolvency resolution. An insurer is normally funded long-term. Therefore, it is likely that assets can be wound down over a longer period of time and immediate large losses to counterparties are unlikely (Thimann 2014). Similarly, according to IAIS (2011) size enables the insurer to better diversify and pool risk. Nevertheless, size could also be due to risk concentration. Moreover, size plays a role if an institution has a very complex structure (IMF, FSB and BIS 2009).

The second criterion is lack of substitutability. In order to be systemically important, institutions have to provide a service that is critical for the economy. In addition, this service cannot be easily taken over by other institutions. An example would be the failure of many banks that leads to shortage of credit or a failure of the payment system. Although insurance services are important for the economy, it seems unlikely that there is immediate harm if insurance provision is interrupted. In case of life insurance, hedging mortality risk is not as important for the functioning of the economy as many banking activities. Also in the case of non-life insurance, immediate severe consequences for the real economy are unlikely (Cummins and Weiss 2013). Baluch, Mutenga and Parsons (2011) point out that the price of insurance might increase in case of distress but it is unlikely that any common form of insurance is not sold at any price. However, insurers do not only provide insurance services but they also play an important role as investor. If the insurance sector stops financing the real economy, this might have indeed negative consequences (Acharya and Richardson 2014).

The third criterion is interconnectedness. In order to trigger a chain effect, a systemically relevant institution has to be connected to other market participants. Not only is the number of links important but also the size of exposures (IMF, FSB and BIS 2009). As it was pointed out before, banks are linked through interbank exposures while insurers do not rely on

funding from each other. However, there is some intra-sector connectedness due to reinsurance bought by from the same reinsurer. Nevertheless, Cummins and Weiss (2013) conclude that reinsurers do not increase systemic risk significantly because they are not highly interconnected with other sectors. With regard to inter-sector linkages, interconnectedness for traditional insurers is supposed to be low (Cummins and Weiss 2013). However, recently many studies find increased spillovers between insurance and other sectors, especially the banking sector (Baluch, Mutenga and Parsons 2011). For example, linkages could be created if an insurer holds banks' bonds or belongs to a financial conglomerate. Therefore, there might be some insurers that have significant linkages to other sectors and qualify as systemic institution according to this criterion.

To sum up, the insurance sector does not seem immune to systemic risk. Especially, the last criterion of interconnectedness will be analyzed by this thesis. If interlinkages among sectors increase, this means that systemic risk increases because a shock would hit a wider part of the financial system and its impact could be more severe. The next parts will consider how systemic risk can be measured in a regulatory and academic context and look at empirical findings on systemic risk in the insurance sector.

3.3 Regulatory response to systemic risk in the insurance sector

The observations made during the crisis led researchers and regulators to analyze systemic risk in the insurance sector. Especially, the failure of AIG drew attention to this sector. Regulators identified global systemically important insurers (GSIIIs) that pose a risk to the financial system and the real economy (IAIS 2013a). The International Association of Insurance Supervisors (IAIS) introduced policy measures that aim at identifying and regulating such insurers. Beginning in 2019, GSIIIs will be required higher capital for loss absorbency and be subject to enhanced supervision.

The initial criteria to identify GSIIIs included size, global activity, substitutability, interconnectedness and non-traditional non-insurance activities. The last two categories receive the highest weights. In 2016, the framework was partly revised and the IAIS introduced a more detailed definition of products and policies that could make an insurer systemically risky. Identification is based on indicators such as derivatives trading or counterparty exposure (IAIS 2016). The IAIS acknowledges that traditional insurance activities are not inherently risky. Especially with regard to size, the IAIS (2013) points out that size enables insurer to pool and diversify risk. However, an insurer could become

systemic through engagement in non-traditional non-insurance activities and increased interconnectedness with other financial market participants (IAIS 2013a).

The Basel Committee's on Banking Supervision methodology to identify global systemically important banks (GSIBs) provides a similar framework. However, indicators and their respective weights vary between the methodology for banks and insurers (IMF 2016). The IAIS (2013a) notes that GSIBs are different from GSIBs as traditional insurance business is not prone to be systemically risky. Thimann (2014) criticizes the IAIS methodology because of its similarities to banking regulation. In his opinion, regulators treat the insurance sector alike to the banking sector despite fundamental differences.

3.4 Measuring systemic risk in the insurance sector

In addition to regulators, academic literature became interested in systemic risk in the insurance sector. Several ways to measure systemic risk are proposed in the literature. These measures often rely on market data instead of balance sheet data like the IAIS approach. Initially, risk measures were applied to measure risk in the banking sector, but, recently, the number of studies on risk in the insurance sector is increasing. In addition, there is increased interest in linkages between banks and insurers.

Several different measures have been developed that relate to different definitions of systemic risk. For example, Acharya, Engle and Richardson (2012) define systemic risk as the risk of a firm to be undercapitalized in a moment the whole system is undercapitalized. In normal times, the default of a bank does not have severe consequences because other firm can take over its services. However, if the whole system is weak, there are no firms which can fill the gap and the financial system is no longer able to perform services such as credit provision. This definition thus follows the macro-systemic risk definition. Following this definition of systemic risk, the measures MES (Acharya et al, 2012) and SRISK (Brownlees and Engle 2015) were introduced to measure the expected capital shortfall of a firm in case of a prolonged market decline. MES relies on the stock returns of a firm in case of a market downturn. SRISK of a firm depends on the firm's size, leverage and expected loss of equity in case of a crisis. Therefore, SRISK and MES relate to the vulnerability of a firm in case of a crisis. Adrian and Brunnermeier (2011) note that pre-crisis periods are often characterized by low volatility. Therefore, risk that is building up during boom phases is not captured by MES. Instead, Adrian and Brunnermeier (2011) propose CoVaR as a measure of systemic risk. CoVaR measures the value at risk of the whole financial system given that a firm becomes distressed.

Moreover, there are measures that relate to the interconnectedness of a firm (Billio et al 2012, Chen et al. 2014). The more interconnected a system is the higher is the risk of contagion and of economic spillovers. Billio et al (2012) use Granger causality networks to measure interdependence between sectors. Pairwise Granger causality tests are proposed to measure if the stock returns of one firm can predict the returns of another. A more connected firm poses higher risk. In contrast to other measures, this measure identifies possible sources and victims of a systemic crisis. The different measures capture different aspects of systemic risks. Therefore, it might be useful to apply more than one measure of systemic risk in order to get broad picture of the systemic riskiness of a firm.

The observations made during the crisis led to many academic studies that apply those measures to quantify systemic risk in the insurance sector. For example, Engle, Jondeau and Rockinger (2015) use the SRISK measure and find that from 2000 to 2012 the insurance sector on average contributed 22% of total capital shortfall of European financial institutions while 77% are attributed to the banking sector. Similarly, Gehrig and Iannino (2016) evaluate SRISK for a longer period of time. They find that since 1996, the systemic risk measure has steadily increased in the insurance sector. In summary, these studies find that the insurance sector is vulnerable to a financial crisis.

Studies are not only interested in quantifying systemic risk in the insurance sector but also look at the interconnectedness of the insurance sector. Interconnectedness is an important element of systemic risk. As it was pointed out before, the crisis was perceived as a banking crisis that spread to the insurance sector. For example, Baluch, Mutenga and Parsons (2011) investigate correlation between major banking and insurance indices. By analyzing a selected group of insurers and banks, they conclude that co-movements are increasing. In addition, Billio et al. (2012) analyze the directionality of relationship between different financial sectors. In order to analyze whether an industry is the source or the victim of a systemic crisis, they apply their network measure based on Granger causality. They find increasing interconnections between different parts of the financial system. The number of connections was especially high during the financial crisis. Banks and insurers seem to have a stronger impact on brokers and hedge funds than vice versa. Chen et al. (2013) conduct a similar analysis based on CDS spreads. They conclude that banks have a stronger influence on insurers than vice versa and that insurers tend to be the victims of systemic risk. Regulators should therefore focus on how to mitigate adverse spillovers from the banking sector to the insurance sector. However, other authors regard insurers as a potential source of systemic risk

(Acharya and Richardson 2014). In this case, possible spillovers from the insurance sector would be a threat to the banking sector.

With regard to insurers' characteristics, Cummins and Weiss (2013) and Weiß and Mühlnickel (2013) analyze the relationship between SRISK and specific features of insurance companies. Both confirm that increased SRISK seems to be linked to non-traditional insurance activities of life and non-life insurers. Moreover, Billio et al. (2012) test whether their Granger causality measure is related to specific characteristics of firms in their sample. They do not find conclusive results. However, their sample consists of firms from different financial sectors. It is not clear whether they run separate regressions for each sector. Insurers' characteristics that increase their interconnectedness might differ from features that are relevant for the interconnectedness of a bank.

The findings of recent studies point to increased interconnectedness of the insurance sector and increased systemic risk. If shocks are transmitted beyond one sector, systemic risk is increasing. Increasing interconnectedness raises the question for the distinct channel through which the insurance sectors is connected to the banking sector. Many authors point to non-insurance products that are seen as responsible for increasing connections to the banking sector. Thus, insurers that pursue different business models and different investment strategies might differ in their interconnectedness to banking sector. Knowledge on how shocks could be transmitted between the two sectors could help to mitigate systemic risk more effectively.

4 Interconnections between banks and insurers

This section examines how the banking and the insurance sector are interlinked. Interconnections can be created by direct or indirect channels. Direct linkages are based on contractual claims that expose institutions to counterparty risk. Examples could be loans to other financial institution or intra-group exposure. If one institution defaults, counterparties of the defaulting institutions might get into difficulties as well. Next, other institutions that are linked to those counterparties experience difficulties. This could lead to chain or domino effects as institutions are hit one after the other by a shock (Kaufmann 2000). Many studies analyze these domino effects, especially with regard to the interbank market. For example, Allen and Galle (2000) analyze contagion through overlapping claims in the banking system and conclude that the likelihood of such contagion depends on the structure of the interbank market.

Even if institutions are not directly linked through their balance sheets, a shock could be transmitted from one firm to the other. Two indirect channels are fire sales and information spillovers. Holdings of common or correlated assets could expose firms that are not directly linked to a “fire sale externality” (Clerc et al. 2016). Shleifer and Vishny (2011) describe fire sales as a situation in which a market wide shock forces market participants to sell assets. Other market participants who are active in the same market are not able to buy the assets because they are themselves financially constrained. The consequence is severe pressure on the price of this asset and financial losses for firms that hold this asset. Fire sales were observed during the financial crisis of 2008. After bad news about the housing market became public and Lehman Brothers collapsed, banks were not able to obtain short-term financing anymore and had to sell assets. Moreover, some of their assets were downgraded, which forced banks to sell them for regulatory reasons. As most market participants were selling their assets instead of buying assets, asset prices collapsed and financial intuitions suffered huge losses (Shleifer and Vishny 2011). Another indirect transmission channel of shocks are information spillovers. Bad news about one firm can negatively impact other firms. If one firm experiences difficulties, market participants reexamine other units that seem to have a similar risk profile. A firm could be perceived as similar because it is active the same markets, has a similar behavior or because it is the same type of institution. Information spillovers are not necessarily irrational. While “information-based” spillovers take into account characteristics of the triggering event or fundamentals of the involved firms, “pure” information spillovers hit all firms equally. Such spillovers that are caused by uninformed

agents are regarded as particularly dangerous (Kaufmann 2000, Cummins, Wei, and Xie 2012).

Various direct and indirect linkages can be found between banks and insurers. They can be created by traditional and non-traditional banking activities. Therefore, this section first presents direct and indirect linkages that traditional insurers could have to the banking sector. The second part investigates which non-traditional insurance activities can increase the interconnectedness of insurers.

4.1 Linkages through traditional insurance activity

4.1.1 Bancassurance and conglomerates

In Europe, insurers and banks seem to be strongly linked because of the popularity of the so-called “bancassurance” model. This model refers to banks providing insurance products and services. The alliance between banks and insurers could take various forms. A bank could act a pure intermediary that is paid a commission or there could be a strategic alliance that obliges the bank to solely distribute products from one partner (Teunissen 2008). The strongest form of bancassurance are financial conglomerates. This term refers to insurance companies and banks that are part of the same group. In general, financial conglomerates are financial groups that engage in different financial activities. European legislation defines a financial conglomerate more narrowly as a group that is active in the insurance and the banking sector (EU Directive 2002/87/EC).

In Europe, the Second Banking Directive in 1989 allowed for such models and lead to increased popularity of bancassurance. Today, the distribution of life insurance is dominated by bancassurance in many European countries. However, this model is not equally important for the distribution of non-life insurance (Artikis, Mutenga and Staikouras 2008). Moreover, deregulation increased the number of mergers and acquisitions within the financial services sector including the insurance industry. In 2015, regulators identified 78 conglomerates within the European Union (EBA 2016).

Incentives for mergers between banks and insurer are increased economies of scale and scope. Economies of scope could be realized through the provision of insurance products through bank branches. Moreover, diversification can lead to lower income volatility as income is generated by different sources (Cumminis and Weiß 2004). Despite those advantages of financial conglomerates, there are several weaknesses. Conglomerates might be complex and opaque, which poses challenges to risk management (ECB 2013). Moreover, bancassurance

could intensify contagion from banks to insurer and vice versa. Direct channels of contagion could be established by intra-group lending or guarantees. Intra-group exposures can facilitate risk transfer within the financial group and lead to contagion. Moreover, if a crisis hits one sector, the unit that is active in this sector might seek support from stronger units active in other sectors. In addition, indirect channels such as reputational channels could be established if a group is engaged in both the banking and the insurance sector. Difficulties in one unit could erode confidence in whole group. Finally, if insurers are active in bank-like activities, diversification benefits might not be achieved (Tower and Impavido 2009, Baluch, Mutenga, & Parsons 2011). The strong affiliation of European banks and insurer through ownership links make information spillovers even more likely as the increased links are recognized by investors and clients. Also with regard to looser cooperation between banks and insurers, those channels could become relevant. An insurer might suffer if its business partner is hit by a shock, or reputational risks might become an issue if customers associate the name of bank with a certain insurance company.

The recent financial crisis highlights these weaknesses of bancassurance groups. Many of the financial groups that received state aid during the crisis were bancassurance groups. However, it is noted that not all of them qualify as conglomerates according to EU legislation. Most calls for state aid were originated by the banking units of the groups, which points to stronger contagion from banks to insurers than vice versa (ECB 2013). Baluch, Mutenga, & Parsons (2011) cite the example of the insurer Allianz that was hit by the crisis due to its ownership of Dresdner Bank and not its core business in the insurance sector.

The importance of ownership ties and operational partnerships of European banks and insurers highlights an important transmission channel between firms of the different industries. Financial integration seems to play an important part in the increased interconnectedness of the banking and the insurance sector. This leads to the first null hypothesis:

Null Hypothesis 1: Being part of a conglomerate is not correlated with an insurer's connectedness to banks

4.1.2 Investment in bank bonds

In addition to ownership ties and operational partnerships, cross-holdings of debt between the banking and the insurance sector could explain increased interconnectedness. In Europe, insurers play an important role in the funding of bank debt. According to the EIOPA (2016), bonds of financial corporates made up 15% of the investment of the life insurance sector in

2015. Non-life insurers invested even more in financial corporate bonds. Banks bonds account for the second largest part of insurers' investment after sovereign bonds. Especially with regard to long-term banks debt and, in some countries, to covered bonds, insurance companies are an important source of funding for debt (Alves et al. 2015). Their holdings of long-term debt might reflect insurers' ability to provide long-term financing. Covered bonds are different from normal bank debt because they are backed by a pool of collateral to which an investor has preferential access in case of financial difficulties of the issuer. The collateral pool normally consists of high-quality mortgages and public sector loans. Covered bonds are an attractive investment for insurers as they offer higher ratings and more security than traditional debt or other forms of credit risk securitization (Packer, Stever and Upper 2007). Although covered bonds are supposed to be safer than unsecured bank debt, the covered bonds market suffered during the financial crisis of 2008. The ECB intervened by purchasing covered bonds to support the market (Beirne et al. 2011).

Alves et al. (2015) analyze the network of direct linkages between EU banks and insurance companies by using data on exposures of insurers. They find only limited contagion risk. Even a shock that hits all top ten banking exposures of an insurance firm simultaneously would only threaten the solvency position of two out of 29 insurance companies. This indicates sound solvency positions and low concentration of exposures. However, the analysis did only consider top ten exposures. There was no data on banks' exposures to insurers, which could provide information on contagion from insurers to banks. Therefore, the analysis does not preclude transmission of shocks through direct exposures.

Insurers' holdings of bank debt create a direct linkage between the two sectors. The default of a bank could hit an insurer directly if it is a creditor of this banks. On the other hand, a crisis in the insurance sector could mean that banks lose an important source of funding. This leads to the following hypothesis:

Null Hypothesis 2: An insurer's investment in bank bonds is not correlated with its connectedness to banks.

4.1.3 Investment in equity and bonds

After having looked mainly at direct channels between banks and insurer, this sector will look into indirect connections between banks and insurers that could stem from the traditional activities of insurers. Fire sales are an indirect channel that could propagate a shock to other sectors if banks and insurers are holding similar assets. Indeed, both are holding bonds and equities.

The question that arises in this context is whether it is likely that insurers engage in fire sales. Insurers are important investors and a pro-cyclical behavior that aggravates price movements could have severe consequences. However, while fire sales are a risk in the banking sector that relies on short-term funding, they should be much less likely in the insurance sector which is able to hold assets to maturity. Therefore, there is less pressure to react immediately to short-term downward movements in a market. Insurers would even be in a position to stabilize the system in case of a crisis (Bank of England 2014).

On the other hand, there seems to be at least some evidence of pro-cyclical behavior of insurers. In 2000, European insurance companies suffered from a stock market decline because they had invested heavily in equities. Reasons were the search for higher returns and deregulation that allowed for new insurance products and guaranteed minimum returns. When stock markets started to decline, insurers sold large portions of their portfolio. In addition, rating agencies exerted pressure and the risk models of insurers lead them to sell equities (IMF 2004). However, through sales insurers had to realize losses and were not able to profit when equity prices rose again. Tower and Impavido (2009) state that that sales might have contributed to the downward movement of the market, but the behavior of insurers does not seem to have hit banks substantially. With regard to recent evidence, Bijlsma and Vermeulen (2015) investigated the behavior of Dutch insurance companies during the European sovereign debt crisis. They found that a “flight to quality” took place during crisis. Dutch insurance companies sold sovereign bonds of southern European countries and bought northern European assets. The authors note that the debt crisis was unique and put the largest asset class of insurers at risk, which might have led to this pro-cyclical behavior. In theory, capital regulation could also lead insurers to sell assets if they make downgraded assets more expensive to hold. Manconi et al. (2011) find that during the financial crisis only insurers with low capital sold securitized bonds. It should be noted that flexible regulation in times of market stress could limit regulatory incentives for pro-cyclical behavior (Bank of England 2014). Also during the equity crisis of 2000, regulators contributed to reduce pressure on insurers (IMF 2004). To sum it up, although there is mixed evidence, there is the potential of insurers engaging in fire sales. At least in theory, it is possible that insurers are driven to sell assets at falling prices. Thus, if banks sell large proportions of a common asset, the insurance sector could be hit. Moreover, insurers might trigger a downward spiral themselves.

The likelihood of fire sales depends on an insurer’s investment portfolio. A more conservative portfolio makes fire sales less likely. Fixed income securities will suffer less during a crisis than other securities such as stocks. As the IMF (2004) points out, equities do not match

insurers' liabilities as well as fixed income securities because they are characterized by higher volatility. The equity crisis from 2000 to 2003 highlights risks that stem from high equity investments. Moreover, as pointed out above, lower rated bonds could lead insurers to engage in pro-cyclical behavior due to regulatory reasons. Lower rated bonds lead to higher capital charges. Equity investments and junk bonds could thus increase interconnectedness with the banking sector due to fire sale externalities. This leads to the following hypotheses:

Null Hypothesis 3: An insurer's investment in equity is not correlated with its connectedness to banks.

Null Hypothesis 4: An insurer's investment in bonds of high quality is not correlated with its connectedness to banks.

4.1.4 Investment in sovereign bonds

Another part of insurers' traditional investment portfolio that could link them to banks are sovereign bonds. As pointed out above, the largest part of the investment portfolio of life and non-life insurers is made up by government bonds. On the other hand, the banking sector is an important source of funding for the public sector. In the Eurozone, banks often hold a large portion of their domestic sovereign debt (Lenarčič, Mevis and Siklós 2016). In Europe, bank capital regulation sets incentives to hold sovereign debt because banks do not face any capital charges for EU government bonds. However, as the sovereign crisis has shown, sovereign bonds are not risk-free (Lenarčič, Mevis and Siklós 2016). It should be noted that Solvency II also applies zero risk weight for sovereign bonds, which could even increase insurers' engagement in this asset class (Düll, König and Ohls 2015). The importance of sovereign bonds as an investment for both sector could strengthen interconnectedness. An example is the selling of bonds of southern European countries by insurers that was observed by Bijlsma and Vermeulen (2015) during the European sovereign debt crisis. Such a behavior might exacerbate price movements, which could in turn hit other investors such as banks. On the other hand, if banks have to sell sovereign bonds, insurers might be hit due to their strong exposure to this asset class.

The high proportion of investment in sovereign bonds might also point to another indirect channel that became visible during the sovereign debt crisis. Acharya, Drechsler, and Schnabl (2014) compare banks bail outs by the government to a "pyrrhic victory". A bail out requires governments to issue additional debt. If tax income is not increased in order to pay back increased debt, existing debtholders such as insurers could be diluted and the creditworthiness of the sovereign is destroyed. This could be the case if the debt of a sovereign is already large

and there is no room for additional tax increases. Moreover, the worsening of the creditworthiness can lead to a feedback loop to the banking sector, which might profit at first from government guarantees, but holds itself large portions of government debt and is hit by a downgrading of sovereign debt. Acharya, Drechsler, and Schnabl (2014) give the example of the announcement of governmental guarantees for banks deposits in Ireland. After this announcement, CDS spreads of Irish banks decreased while the cost for Irish sovereign debt increased. They also find confirmation for the thesis that increased sovereign risk weakened the financial sector.

Thus, a crisis in the banking sector could have severe consequences for the insurance sector. As it has invested heavily in sovereign bonds, a downgrading of such bonds due to bank aid could deteriorate the quality of an insurer's investment portfolio. Düll, König and Ohls (2015) analyze CDS spreads of sovereigns and insurers and find that the insurers' default risk is dependent on sovereign default risk. This means if banks increase a sovereign's default risk, they indirectly increase the insurer's default risk.

These findings lead to the following null hypothesis:

Null Hypothesis 5: An insurer's investment in sovereign debt is not correlated with its connectedness to banks.

4.1.5 Derivatives

In order to match assets and liabilities, insurance companies make use of derivatives that hedge market risks. The main classes of derivatives on insurers' balance sheets include interest swaps and options (Alves et al. 2015). It should be noted that many jurisdictions prohibit speculative derivatives trading by law (ESRB 2015). Banks are also active in derivative markets because they hedge credit and trading risk (Al-Darwish et al. 2011). However, derivatives do not make risks disappear as they are passed on to other market participants (IAIS 2016). Insurers' exposure to the markets for hedging instruments could make them more vulnerable to a market downturn that is triggered by banks that are active in the same market. Insurers' costs of hedging increase in adverse market conditions (Tower and Impavido 2009). Moreover, as both banks and insurance companies are active in derivative markets, counterparty risk could be established. This leads to the following null hypothesis:

Null Hypothesis 6: An insurer's investment in derivatives is not correlated with its connectedness to banks.

4.2 Linkages through non-traditional insurance activities

So far, it was examined how the traditional business model of insurers could create links between the banking and insurance sector. However, insurers are increasingly engaged in non-core activities that lack essential characteristics of traditional insurance activities. This section will examine how linkages can be created because of such activities.

Non-traditional activities increase interconnectedness between the banking and insurance sector through direct and indirect linkages. On the one hand, counterparty risk is increased through activities presented in this section. On the other hand, insurers are increasingly active in financial markets making contagion through fire sales more likely. Moreover, many of the non-core activities that are presented in this section have characteristics that could make insurance firms more similar to firms operating in the banking sector. Examples are unit-linked products or non-policyholder funding. As it was outlined above, information spillovers could occur if firms are perceived to have a similar risk profile by investors and customers. Cummins, Wei, and Xie (2012) point out that inter-industry spillovers between the banking and the insurance industry are possible because those sectors increasingly offer the same products. They investigated information spillovers between U.S commercial banks, investment banks and insurers after operational loss events that affected a bank or an insurer. They find that there are significant information spillovers between the banking and the insurance sector. They conclude this might be due to the fact that some financial products are offered by both sectors. In addition to counterparty risk and possible market price channels, information spillovers are an important channel through which non-traditional insurance activities can increase spillovers between bank and insurance stock returns.

4.2.1 Unit-linked products

Modern life insurance products are increasingly unit-linked. Like traditional insurance policies, these products provide a possibility to save for retirement or other long-term purposes. Unit-linked means that the return of the customer is linked to a specific fund managed by the insurance company. Typically, policyholders can choose to some extent which investments they prefer to invest their premiums in. Unit-linked products are normally held in separate accounts on an insurer's balance sheet as they are legally separated from other assets of the insurer (Geneva Association 2013). The investment risk the policyholder must bear varies. While some products pass through most of the risk to the customer, others make the insurer bear most of the losses (Tower and Impavido 2009). A common form of unit-linked products are "variable annuities". The EIOPA (2011) defines variable annuities as

unit-linked products that involve partial or total guarantees. Thus, they protect the client from downside movements of the market. Variable annuity contracts have been common in the U.S. and Japan since the 1990s, but, recently, their popularity in Europe has also started to increase (EIOPA 2011).

Life insurance products with guaranteed minimum returns have been offered by life insurers for a long time. Especially in German-speaking countries, such products are regarded as traditional insurance products (Eling and Pankoke 2014). Nonetheless, they can be categorized as non-core insurance products as they expose an insurer to non-diversifiable risk (Acharya and Richardson 2014). Regulators also define a guaranteed return as characteristic that makes insurance products non-traditional. If the insurer has guaranteed a benefit, it might be difficult to find assets that pay the same interest as the one that is guaranteed. Problems can occur if the returns of an insurer's assets are lower than the guaranteed return or if there is a lack of fixed income assets (IAIS 2016). Thus, a guaranteed minimum return exposes an insurer to market developments and poses a threat to the traditional stability of the insurance sector. This is illustrated by the current low interest environment, in which many insurers face difficulties to pay the guaranteed minimum return they promised in the past (EIOPA 2015).

Moreover, variable annuities are non-traditional as they make insurers more dependent on the behavior of policyholders. Early withdrawal is possible under some variable annuity contracts although there might be penalty. Some authors, therefore, identify variable annuities as a possible source of insurance runs. Clients might cancel such policies in times of a crisis (Acharya and Richardson 2014, Grace 2010, Cummins and Weiss 2013). In theory, such an "insurance run" could trigger fire sales and contagion to other market participants such as banks (IAIS 2016). These characteristics make annuities similar to products offered by other financial companies such as banks. In addition, the risk management of variable annuities is very complex. An insurer has to model customer behavior regarding fund choice or early surrender and to hedge guaranteed returns. This increases the demand of insurers for hedging instruments and makes them more sensitive to the development of derivative markets (EIOPA 2011).

To sum, unit-linked products and, in particular, variable annuities have some features that could contribute to increased interconnectedness between the banking and insurance sector. If insurers are more active in derivative markets, potential counterparty risk with banks that are also active in this market increases. If a crisis in the banking sector leads to adverse market conditions, the cost of hedging for insurers might increase significantly (Tower and Impavido 2009). Moreover, variable annuities share some characteristics of banking products, which

might favor indirect contagion. These unit-linked products involve non-diversifiable risk that increases exposure to a crisis triggered by other sectors. In addition, information spillovers are more likely if an insurer offers bank-like products. Investors and customers might no longer be able to clearly distinguish between banks and insurers. According to some authors, variable annuities make insurance runs more likely. This means that in an extreme case scenario, a crisis in one sector could lead to a run in the other sector.

This leads to following hypothesis:

Null Hypothesis 7: Separate accounts of an insurer are not correlated with its connectedness to banks.

4.2.2 CDS and credit risk transfer

Another activity that lacks traditional insurance characteristics is credit risk transfer between the banking and the insurance sector. Credit risk transfer can have various forms. Insurers have historically engaged in credit insurance that protects businesses against failure of payment. Since the 1990s, there has been a rapid development of new forms of credit risk transfer. The most popular instruments are credit default swaps (CDS). A CDS is a derivative contract that insures against the default of an underlying asset such as a corporate bond. However, unlike traditional insurance, in case of a CDS, it is not necessary to be the owner of the underlying assets (Baluch, Mutenga, & Parsons 2011). Another form are collateralized debt obligations (CDOs) that split the risk of the underlying portfolio into different tranches (Rule 2001).

Banking and insurance sector have various motives for transferring credit risk across sectors. The banking sector used credit derivatives to distribute the risk it had originated instead of keeping credit risk on its own balance sheet. Initially, this development was partly driven by regulatory arbitrage that was incentivized by the undifferentiated treatment of bonds by Basel I. However, later the main motives were economic reasons such as lower risk concentration and diversification (IMF 2004; ECB 2007). Credit risk was not only transferred to other banks but also to other sectors, especially the insurance sector. Rule (2001) suggests that one motivation of the insurance sector to take on credit risk was the search for investments that brought higher returns.

The proportion of instruments on European insurers' balance sheets that allows credit risk transfer seems to be small. However, precise data on insurers' holdings is not available (ESRB 2015). In addition, the Joint Forum (2005, 2008) notes that credit risk transfer only amounts to a small proportion of insurers' investment and that investment in instruments such

as CDOs was scaled back after losses were experienced in 2001 and 2002. Nevertheless, it is noted that some large insurance holding companies are actively trading risk. The experience of Swiss Re and AIG shows the risk of concentrations of CDS sales within one firm.

Risk transfer between banking and insurance sector raises the question whether overall risk in the financial sector is reduced through moving risk or if it is simply transferred to less regulated sectors (IMF 2004). During the financial crisis, it became apparent that credit risk transfer does not make credit risk disappear. In the U.S., the insurer AIG heavily engaged in the selling of CDS. Modern CDS did not insure against the default of simple corporate bonds but against the default of complex securities backed by subprime mortgages. This led to the near failure of AIG in 2008. Other examples of firms that suffered during the financial crisis because of their engagement in credit risk transfer are U.S. monoline insurers (Baluch, Mutenga, & Parsons 2011). The example of AIG illustrates how credit risk transfer can increase linkages to the banking sector. On the one hand, an increased number of defaults can pose a risk to the seller of credit risk insurance. In case of AIG, the default of the bank Lehman Brothers contributed to its own bailout. AIG had sold many CDS against a default of Lehman Brothers. On the other hand, a bank that buys credit risk from an insurer increases its counterparty risk with this insurer. A failure of the firm that has sold protection against credit risk means difficulties for the buyer (Baluch, Mutenga, & Parsons 2011). Finally, credit risk transfer could increase information spillovers. If insurers take over risks from the banking sector, investors might perceive that insurers and banks have similar risk profiles.

This leads to the following hypothesis:

Null Hypothesis 8: The involvement of an insurer in credit risk transfer is not correlated with its connectedness to banks.

4.2.3 Insurance linked securities and insurance risk transfer

Not only credit risk is transferred between banks and insurers. Beginning in the 1980s, insurers have developed instruments that allow them to transfer insurance risk to other market participants. Such instruments are captured by the term “alternative risk transfer” (ART). Examples are so-called CAT bonds issued by non-life insurance companies. Principal and interest of these bonds depend on the occurrence of catastrophes such as earthquakes or storms. A Special Purpose Vehicle (SPV) is created that invests the proceeds from selling the bonds. In normal times, the returns of the SPV’s investments are used to pay bondholders. As soon as a catastrophe occurs, insurers receive the returns instead of the bondholders to offset

claims due to this event. These bonds, therefore, allow an insurer to transfer insurance risk to other market participants (Baluch, Mutenga, & Parsons 2011).

Life insurers are also engaged in alternative risk transfer. According to Rule (2001), the main motivation to securitize life insurance risk is to obtain additional funds to finance future growth. A problem in the life insurance business is that initial costs to obtain a new customer might exceed initial premium payment. Also in this case, the risk of increased mortality or surrender rates are borne by the market. Finally, insurance linked securities could increase possibilities of regulatory arbitrage because insurers could shift risks towards banks (Al-Darwish et al. 2011). Investors' motives to buy such instruments include diversification benefits as insurance risk has a low correlation with capital market movements (CEIOPS 2009).

With regard to the market for credit linked securities, the former European insurance authority CEIOPS (2009) notes that linked securities only amount to 1% of world securitization markets. Nevertheless, the market for CAT and for life bonds is growing. With regard to investors, banks make up 13% of investors in CAT bonds while funds that specialize in the management of such bonds make up 44%. In contrast to this, banks are the majority of investors in the life bonds market.

As the banking sector acts a potential buyer of such bonds, increasing engagement in alternative risk transfer could increase links to the banking sector. Increased investment could make insurers dependent on liquidity of the banking sector. Moreover, the risk of information spillovers increases. If a bank's risk exposure becomes more similar to that of an insurer, in case of a crisis, investors might think that difficulties of insurers could point to potential difficulties of this bank.

This leads to the following hypothesis:

Null Hypothesis 9: The involvement of an insurer in alternative risk transfer is not correlated with its connectedness to banks.

4.2.4 Funding

Non-traditional banking activities can also be identified with regard to the funding of insurers. In particular, non-policyholder finance and short-term funding are mentioned in this context. These activities are non-traditional because they are contrary to the traditional insurance model that involves long-term financing by its policyholders. These activities are found to be potential sources of systemic risk (Geneva Association 2010, Cummins and Weiss 2013). Moreover, the extent to which an insurer relies on short-term funding and non-policyholder

liabilities are included in the methodology for identifying global systemically important insurers (IAIS 2016a).

First, insurers could try to enhance yields by raising short-term funds and invest those funds in assets that promise a higher return. This strategy is similar to bank's business model. Insurers could use their high credit rating when raising short-term funds to obtain favorable interest rates (Geneva Association 2010). It should be noted that, in contrast to the banking sector, the use of commercial paper is not very common in the insurance sector (Eling and Pankoke 2014). Repurchase agreements (repos) and securities lending are forms of short-term financing that are much more relevant for the insurance sector. In such transactions, one party borrows cash or a security. As a collateral the borrower transfers the ownership of an asset to the lender. The lender can, thus, reuse the collateral as its legal owner until the transaction ends and the collateral has to be given back to the borrower. While the overall share of insurers in collateral markets is relatively low, it seems that insurers are important for securities lending. Insurers and pension funds hold 37% of the assets available for securities lending (Keller et al. 2014). Insurers typically hold assets long-term. Therefore, they can try to enhance their yields by lending their assets to other market participants and reinvesting cash collateral they receive (Adrian et al. 2013).

The case of AIG illustrates the risks connected to such transactions, especially securities lending. Like other insurers, AIG engaged in securities lending. It invested the cash collateral that it had received for lending its assets in mortgage-backed securities. These securities became illiquid during the financial crisis of 2008. Therefore, AIG could not sell those assets in order to repay collateral and it suffered from insufficient liquidity (Acharya and Richardson 2014). Banking counterparties of such transactions would thus have been directly hit if the U.S. government had not intervened. AIG's counterparties included large banking groups like Barclays, Deutsche Bank and BNP Paribas (Geneva Association 2010). The importance of securities lending for European insurers make it likely that similar connections are relevant here.

With regard to the connectedness between the banking and the insurance sector, short-term funding strengthens the ties between the two sectors if the banking sector provides short-term finance to insurers. On the one hand, insurers are getting more vulnerable to a crisis in the banking sector if it relies on short-term funding from this sector. Moreover, indirectly, reliance on short-term funding means that in case of a dry-up of this short-term liquidity, the insurer has to sell assets to pay back debt which could lead to fire sales that hit the banking sector.

Null Hypothesis 10: Relying on short-term funding is not correlated with an insurer's connectedness to banks.

Non-traditional insurance funding does not only include short-term financing but also non-policyholder funding in general (Weiß and Mühlnickel 2013, IAIS 2013). Non-policyholder liabilities refer to short-term and long-term funding that is not originated from inflows from policyholders. Again, search for a higher yield could be a motive to increase such liabilities (EIOPA 2015).

With regard to interconnectedness, direct channels could be established if the insurance sector increases its reliance on non-policyholder funding, especially from the banking sector. Nevertheless, the importance of direct loans from the banking to the insurance sector seems limited. The ESRB (2015) notes that direct banks loans to insurers are forbidden in many countries. Even though it is possible to circumvent regulations by taking out a loan through a non-insurance subsidiary, total bank loans to euro-area insurance companies only make up 101 billion Euro. Total bonds issued by the insurance sector only amounted to 32 billion Euro. However, half of these bonds were held by the banking sector. If a bank has invested heavily in the bonds of an insurer, direct linkages in both directions could be established.

Moreover, interconnections through indirect channels could increase if the banking and the insurance sector rely on similar sources of financing. It might be true that similar sources of financing mean that, in case of a banking crisis, it becomes easier for insurers to obtain financing as investors are looking for alternative investments to banks bonds. On the other hand, similar sources of financing could mean that information spillovers have more severe consequences. If an investor perceives that insurers have become similar to banks because the insurer offers bank-like products, assumes credit risk or has a similar investment portfolio to banks, investors could believe that the insurers will be hit by problems similar that of the banking sector. Thus, the investor might refuse to finance an insurer in case of a banking crisis. Moreover, relying on the same sources of funding as the banking sector could strengthen this perception. This discussion leads to the following hypothesis:

Null Hypothesis 11: Non-policyholder liabilities of an insurer are not correlated with its connectedness to banks.

After having set up the theoretical background, the hypotheses established in this section are tested empirically in the second part of this thesis.

5 Methodology and data

To examine the interconnections of the banking and the insurance sector and the relevance of recent developments in the insurance for these linkages, two steps are taken. First, a measure of interconnectedness is chosen and the development of interlinkages over time is examined. Second, it is tested whether specific characteristics that relate to possible channels of risk transmission could influence the connections individual insurers have to the banking sector.

5.1 Methods

5.1.1 Granger causality test

To measure interlinkages between the banking and the insurance sector, return spillovers between the two sectors are examined. Following Billio et al (2012), the measure used is based on Granger causality tests of stock returns. Granger causality means that past values of one variable contain information on the current value of another variable. Suppose B_t^i is the stock return series of a bank and I_t^j is the return series of an insurer. Following Billio et al. (2012) their relationship can be modelled the following way:

$$B_{t+1}^i = \alpha^i B_t^i + \beta^{ij} I_t^j + e_{t+1}^i$$

$$I_{t+1}^j = \alpha^j I_t^j + \beta^{ji} B_t^i + e_{t+1}^j$$

After having set up this model, the dependent variable is regressed on its own lags and the lagged values of the other variable. Next, it can be tested whether the coefficients are significantly different from zero. For example, if β^{ij} is different from zero, the lags of I_t^j contain information on the current value of B_t^i . The returns of the insurer would thus Granger cause the returns of the bank. If β is significant in both equations, there would be a bi-directional relationship between the returns of banks and insurer (Brooks 2008). If none of the two β is significant, it is assumed that there are no significant lead-lag relationships between the returns of the two firms. A model that models a variable as dependent on previous lags of itself and the lags of another variable is called a Vector Autoregressive (VAR) model (Brooks 2008).

This measure enables the analysis of how the number of connections between the insurers and the banks of my sample changed over time. Moreover, this measure provides information on whether insurers are more likely to be the source or the victim of a shock that hits the banks of my sample. Finally, the numbers of connections the individual insurers have to banks of the

sample can be compared in order to find those insurers that seem to be more closely interlinked with the banking sector.

Some authors criticize the use of this measure. For example, Grace (2010) finds Granger causality between the AIG bail-out and major market indices. However, he concludes that Granger causality tests make it impossible to say whether AIG caused a market downturn or if it simply experienced events before the market did. Similarly, Acharya, Engle and Richardson (2012) write that because of this weakness of the measure of Billio et al (2012), other measures of individual weakness such as MES should be preferred. However, Billio et al. (2012) also test their Granger causality measure on a series corrected for common exposure. They regress returns series on the S&P 500 and redo the analysis with the residuals. They obtain very similar results to the initial test. It should also be noted that the number of connections does not indicate the size of exposures. A high number of connections does not necessarily indicate high risk if the total exposure of its counterparties to the failing firm is low (Acharya and Richardson 2014).

Despite this criticism, the Billio et al. (2012) measure is better suited for the purpose of this thesis than the SRISK or MES measure. The aim of the thesis is to examine the increased interlinkages between the banking and the insurance sector. SRISK and MES examine the vulnerability of an institution but they do not provide information on the relations between individual firms. The focus of this measure is on the interconnectedness element of systemic risk. With regard to the CoVar measure of Adrian and Brunnermeier (2011), Billio et al. (2012) note that this measure concentrates on periods of extreme losses and might thus miss the buildup of additional linkages during normal times. Moreover, other measures do not enable the analysis of the directionality of relationships between banks and insurers.

To conduct pairwise Granger causality tests the following steps are taken. First, Akaike's information criterion (AIC) is used to select the optimum number of lags for each pair of institutions. If the AIC suggest to include no lags for one pair, it is assumed that there is no Granger causal relationship between these two institutions. Next, VAR models are set up for each pair of institutions and it is tested whether the VAR models are stable. A Lagrange multiplier test for the joint null hypothesis of no auto-correlation of the residuals is run. Finally, a Granger causality test is run based on the VAR models.

Before conducting the Granger causality test, a Dickey-Fuller test is conducted to test whether a unit root is present in the data (Brooks 2008). Moreover, return series are corrected for heteroscedasticity as financial asset returns are characterized by volatility clustering. This characteristic can be modelled by autoregressive conditionally heteroscedastic (ARCH)

models. One widely used form are generalized ARCH (GARCH) models that estimate the variance (Brooks 2008). Following Billio et al. (2012), a GARCH (1,1) model is used to control for heteroscedasticity. The conditional variance of each return series is estimated by a GRACH model. To filter out heteroscedasticity, the return series is divided by the fitted variance.

The STATA commands used can be found in the appendix.

5.1.2 Kruskal-Wallis test and Spearman's rank correlation coefficient

In order to investigate possible explanations for different levels of connectedness among insurers, characteristics of the insurers of my sample are compared to the number of Granger linkages an insurer has. First, it is investigated whether specific groups of insurers are more strongly connected to the banking sector. Second, it is analyzed if certain balance sheet items can explain higher connectedness.

In particular, non-parametric methods that are based on rankings are applied. The advantage of non-parametric methods is that they can be applied if it is not certain that data is normally distributed with equal variances. First, a non-parametric Kruskal-Wallis test is conducted to determine whether differences in connectedness between different groups of insurers are significant. A Kruskal-Wallis test is a non-parametric test which tests whether two groups are identical. It can also be applied for more than two groups. The test first ranks all items based on one variable and then calculates the Kruskal-Wallis test statistic. Finally, it can be examined whether the mean ranks of the groups are different. Second, the Spearman Rank-Correlation coefficient is applied to measure correlation between Granger connections and balance sheet items. The Spearman rank-correlation coefficient measures the correlation between the ranks of two items (See, for example, Anderson, Sweeney and Williams 1999).

5.2 Sample and data

5.2.1 Sample and returns

My sample includes the largest 15 banks, 15 diversified financials and 30 insurance companies from the Eurozone, Switzerland and the UK. Institutions are classified according to Global Industry Classification Standard (GICS). The banking sector is represented by banks and diversified financials. The latter category was included to get a broader picture of the banking sector because this category includes banks such as Deutsche Bank AG, investment banks and conglomerates such as Banca Mediolanum. In the following, "banks" will be used to refer to those firms of my sample that belong to the GICS-groups "Banks" and

“Diversified financials”. Firms were selected based on average assets between 2000 and 2014. At the time of selection data for 2015 was not available yet for all firms.

Daily return series of each firm and total assets were obtained from Compustat Global via the platform WRDS. Exchange rates were available from the ECB’s homepage (ECB 2016). In addition, the database Datastream (DS) was used for monthly returns of each firm as monthly data is not provided by Compustat Global. Firms with less than 250 daily observations of returns per year from 2000 to 2015¹ were excluded in order to select those firms for which complete data was available. If Compustat Global provided several issues for one company, the issue with most observations was selected. In addition, it was checked that data for all selected firms was available from Datastream and SNL Finance.

The selected firms are presented in *Table 1*. Regarding the insurers of the sample, most come from the UK followed by France, Great Britain and Switzerland. Half of the insurers are Multi-line insurers.

The Granger causality measure is calculated for five periods of three years from 2001 to 2015. During the first period from 2001 to 2003, European insurers were hit by a downturn of the equity market. 2004 to 2006 represents the pre-crisis period while the failure of Lehman Brothers and the following financial crisis took place during the period from 2007 to 2009. Next, the sovereign debt crisis took place from 2010 to 2012 and the most recent period is from 2013 to 2015. With regard to regulation, the periods encompass the introduction of Solvency I and Basel II in the period from 2004 to 2006 and the adoption of Basel III in 2013 (Al-Darwish et al. 2011). Solvency II was introduced in 2016 after the last period ended.

Table 2 and *3* summarize monthly and daily returns of the selected institutions from 2001 to 2015.

¹ In particular, firms with less than 4000 observations (250*16) were excluded.

Table 1: Sample insurers and banks

Banks	GICS Industry	GICS Sub-Industry	Country	Gvkey (WRDS)	Ticker (DS)
3i Group PLC	Diversified Financials	Asset Management & Custody Banks	GBR	210835	III
Banca Mediolanum	Diversified Financials	Other Diversified Financial Services	ITA	212955	I:BMED
Banco Bilbao Vizcaya Argentaria SA	Banks	Diversified Banks	ESP	15181	E:BBVA
Banco Santander SA	Banks	Diversified Banks	ESP	14140	E:SCH
Barclays PLC	Banks	Diversified Banks	GBR	12673	BARC
BNP Paribas	Banks	Diversified Banks	FRA	15532	F:BNP
Commerzbank AG	Banks	Diversified Banks	DEU	15575	D:CBK
Credit Suisse Group	Diversified Financials	Diversified Capital Markets	CHE	28838	S:CSGN
Deutsche Bank AG	Diversified Financials	Diversified Capital Markets	DEU	15576	D:DBK
Dexia SA	Banks	Diversified Banks	BEL	24596	B:DEXB
Eurazeo	Diversified Financials	Multi-Sector Holdings	FRA	15908	F:ERF
Gam Holding Ltd	Diversified Financials	Asset Management & Custody Banks	CHE	15805	S:GAM
Groupe Bruxelles Lambert SA	Diversified Financials	Multi-Sector Holdings	BEL	21408	B:GBLN
HSBC Holdings PLC	Banks	Diversified Banks	GBR	15509	HSBA
ICAP PLC	Diversified Financials	Investment Banking & Brokerage	GBR	224886	IAP
ING Groep NV	Banks	Diversified Banks	NLD	15617	H:INGA
Intesa Sanpaolo SPA	Banks	Diversified Banks	ITA	16348	I:ISP
Lloyds Banking Group PLC	Banks	Diversified Banks	GBR	15929	LLOY
Man Group PLC	Diversified Financials	Asset Management & Custody Banks	GBR	223489	EMG
Mediobanca	Diversified Financials	Investment Banking & Brokerage	ITA	15593	I:MB
Natixis	Banks	Diversified Banks	FRA	15547	F:KN@F
ParagSA Holding SA, Geneve	Diversified Financials	Multi-Sector Holdings	CHE	23445	S:PARG
Royal Bank of Scotland Group PLC	Banks	Diversified Banks	GBR	15634	RBS
Schroders PLC	Diversified Financials	Asset Management & Custody Banks	GBR	15638	SDR
Societe Generale Group	Banks	Diversified Banks	FRA	15784	F:SGE
Standard Chartered PLC	Banks	Diversified Banks	GBR	15645	STAN
Unicredit SPA	Banks	Diversified Banks	ITA	15549	I:UCG
Vontobel Holding AG	Diversified Financials	Asset Management & Custody Banks	CHE	21481	S:VONN
Wendel	Diversified Financials	Multi-Sector Holdings	FRA	103172	F:MF@F
Wuestenrot & Wuertembergische AG	Diversified Financials	Other Diversified Financial Services	DEU	231496	D:WUW
Insurer	GICS Industry	GICS Sub-Industry	Country	Gvkey (WRDS)	Ticker (DS)
Aegon NV	Insurance	Life & Health Insurance	NLD	15598	H:AGN
Ageas SA/NV	Insurance	Multi-line Insurance	BEL	16447	B:AGS
Allianz SE	Insurance	Multi-line Insurance	DEU	15724	D:ALV
Amlin PLC	Insurance	Property & Casualty Insurance	GBR	223502	AML
Assicurazioni Generali SPA	Insurance	Multi-line Insurance	ITA	15804	I:G
Aviva PLC	Insurance	Multi-line Insurance	GBR	15545	AV.
Axa	Insurance	Multi-line Insurance	FRA	63120	F:MIDI
Baloise-Holding	Insurance	Multi-line Insurance	CHE	23087	S:BALN
CNP Assurances	Insurance	Life & Health Insurance	FRA	225244	F:CNP
Euler Hermes Group	Insurance	Property & Casualty Insurance	FRA	237105	F:EULE
Grupo Catalana Occidente SA	Insurance	Multi-line Insurance	ESP	212641	E:GCO
Hannover Rueck SE	Insurance	Reinsurance	DEU	204825	D:HNR1
Helvetia Holding AG	Insurance	Multi-line Insurance	CHE	16349	S:HEPN
Jardine Lloyd Thompson Group PLC	Insurance	Insurance Brokers	GBR	25369	JLT
Legal & General Group PLC	Insurance	Life & Health Insurance	GBR	15603	LGEN
Mapfre	Insurance	Multi-line Insurance	ESP	16281	E:MAP
Munich Re	Insurance	Reinsurance	DEU	15677	D:MUV2
Novae Group	Insurance	Property & Casualty Insurance	GBR	223540	NVA
Nuernberger Beteiligungs AG	Insurance	Multi-line Insurance	DEU	208752	D:NBG6
Old Mutual PLC	Insurance	Life & Health Insurance	GBR	229039	OML
Prudential PLC	Insurance	Life & Health Insurance	GBR	15782	PRU
RSA Insurance Group Plc	Insurance	Property & Casualty Insurance	GBR	15664	RSA
Sampo PLC	Insurance	Multi-line Insurance	FIN	15773	M:SAMA
Schweizerische Rentenanstalt	Insurance	Life & Health Insurance	CHE	205699	S:SLHN
Scor SE	Insurance	Reinsurance	FRA	63759	F:SCO
St James Place	Insurance	Life & Health Insurance	GBR	23913	STJ
Unipol Gruppo Finanziario SPA	Insurance	Multi-line Insurance	ITA	15862	I:UNI
UnipolSai Assicurazioni SpA	Insurance	Multi-line Insurance	ITA	15914	I:US
UNIQA Insurance Group AG	Insurance	Multi-line Insurance	AUT	23595	O:UNIQ
Zurich Insurance Group AG	Insurance	Multi-line Insurance	CHE	220426	S:ZURN

Table 2: Monthly returns

Banks	Freq.	Mean	Median	St. Dev.	Min	Max
3I Group PLC	180	-0.0008	0.0010	0.1042	-0.3715	0.3752
Banca Mediolanum	180	-0.0002	0.0047	0.1112	-0.5928	0.3325
Banco Bilbao Vizcaya Argentaria SA	180	-0.0002	0.0042	0.0926	-0.3117	0.2861
Banco Santander SA	180	0.0012	0.0060	0.0923	-0.2902	0.3278
Barclays PLC	180	-0.0007	-0.0012	0.1204	-0.6873	0.5823
BNP Paribas	180	0.0043	0.0097	0.0904	-0.3326	0.3335
Commerzbank AG	180	-0.0148	-0.0067	0.1469	-0.6916	0.4408
Credit Suisse Group	180	-0.0043	-0.0020	0.1000	-0.3609	0.3319
Deutsche Bank AG	180	-0.0041	0.0059	0.1113	-0.5010	0.4606
Dexia SA	180	-0.0315	-0.0019	0.1950	-0.9880	0.8285
Eurazeo	180	0.0051	0.0050	0.0930	-0.3656	0.3570
Gam Holding Ltd	180	0.0028	0.0168	0.1005	-0.3050	0.2845
Groupe Bruxelles Lambert SA	180	0.0041	0.0105	0.0571	-0.2588	0.1876
HSBC Holdings PLC	180	0.0015	0.0020	0.0677	-0.2782	0.2216
ICAP PLC	180	0.0149	0.0165	0.0935	-0.3194	0.3397
ING Groep NV	180	-0.0029	0.0092	0.1326	-0.7337	0.4519
Intesa Sanpaolo SPA	180	0.0006	0.0111	0.1053	-0.3529	0.2771
Lloyds Banking Group PLC	180	-0.0050	-0.0004	0.1123	-0.5796	0.4342
Man Group PLC	180	0.0074	0.0179	0.1090	-0.4723	0.2933
Mediobanca	180	0.0005	0.0037	0.0916	-0.2334	0.3038
Natixis	180	0.0036	0.0042	0.1152	-0.4941	0.5321
Pargesa Holding SA, Geneve	180	0.0022	0.0108	0.0731	-0.3313	0.1600
Royal Bank of Scotland Group PLC	180	-0.0125	-0.0003	0.1428	-1.0155	0.5613
Schroders PLC	180	0.0069	0.0129	0.0919	-0.2875	0.2168
Societe Generale Group	180	0.0015	0.0079	0.1127	-0.4013	0.3429
Standard Chartered PLC	180	0.0012	0.0056	0.0970	-0.3464	0.4449
Unicredit SPA	180	-0.0076	0.0000	0.1058	-0.4401	0.3632
Vontobel Holding AG	180	-0.0003	0.0064	0.1097	-0.3978	0.3097
Wendel	180	0.0077	0.0221	0.1114	-0.3770	0.3431
Wuestenrot & Wuernttembergi. AG	180	0.0013	-0.0108	0.0749	-0.2043	0.2889
Insurers	Freq.	Mean	Median	St. Dev.	Min	Max
Aegon NV	180	-0.0088	0.0091	0.1291	-0.6617	0.2984
Ageas SA/NV	180	-0.0081	0.0108	0.1762	-1.5872	0.5865
Allianz SE	180	-0.0016	0.0086	0.1069	-0.4749	0.4125
Amlin PLC	180	0.0146	0.0130	0.0942	-0.7106	0.3453
Assicurazioni Generali SPA	180	-0.0021	0.0018	0.0786	-0.3058	0.2388
Aviva PLC	180	0.0006	0.0095	0.0875	-0.2602	0.3032
Axa	180	0.0012	0.0102	0.1176	-0.5201	0.3527
Baloise-Holding	180	0.0009	0.0108	0.0885	-0.3391	0.2397
CNP Assurances	180	0.0052	0.0096	0.0749	-0.2559	0.2168
Euler Hermes Group	180	0.0070	0.0152	0.1004	-0.3341	0.3407
Grupo Catalana Occidente SA	180	0.0145	0.0173	0.0912	-0.3370	0.2455
Hannover Rueck SE	180	0.0101	0.0149	0.0840	-0.4321	0.2745
Helvetia Holding AG	180	0.0051	0.0099	0.0912	-0.4278	0.3005
Jardine Lloyd Thompson Group PLC	180	0.0070	0.0152	0.0650	-0.2659	0.1993
Legal & General Group PLC	180	0.0069	0.0134	0.0933	-0.4755	0.2687
Mapfre	180	0.0065	0.0006	0.0862	-0.3470	0.2750
Munich Re	180	-0.0006	0.0048	0.0890	-0.4706	0.4655
Novae Group	180	-0.0006	0.0062	0.1419	-0.9018	0.3735
Nuernberger Beteiligungs AG	180	0.0002	-0.0009	0.0565	-0.2714	0.2364
Old Mutual PLC	180	0.0051	0.0089	0.0930	-0.3288	0.4137
Prudential PLC	180	0.0052	0.0170	0.0989	-0.4432	0.3050
RSA Insurance Group Plc	180	-0.0040	0.0011	0.1058	-0.5027	0.3615
Sampo PLC	180	0.0135	0.0137	0.0691	-0.2256	0.2815
Schweizerische Rentenanstalt	180	-0.0046	0.0016	0.1386	-0.4902	0.5637
Scor SE	180	-0.0049	0.0089	0.1238	-0.9757	0.3556
St James Place	180	0.0075	0.0211	0.0971	-0.3219	0.3074
Unipol Gruppo Finanziario SPA	180	-0.0092	-0.0021	0.1106	-0.5768	0.3858
UnipolSai Assicurazioni SpA	180	-0.0115	-0.0030	0.1438	-0.8047	0.6221
UNIQA Insurance Group AG	180	0.0037	-0.0018	0.0747	-0.1689	0.3271
Zurich Insurance Group AG	180	-0.0021	0.0160	0.1020	-0.7167	0.2927

Note: Data was collected at 1st of each month. Source: Datastream

Table 3: Daily returns

Banks	Freq.	Mean	Median	St. Dev.	Min	Max
3I Group PLC	3,844	-0.0001	0.0000	0.0229	-0.1793	0.1919
Banca Mediolanum	3,852	0.0000	0.0000	0.0241	-0.1142	0.1507
Banco Bilbao Vizcaya Argentaria SA	3,839	0.0000	0.0000	0.0215	-0.1190	0.1991
Banco Santander SA	3,838	0.0000	0.0002	0.0222	-0.1519	0.2088
Barclays PLC	3,844	-0.0001	0.0000	0.0299	-0.2856	0.5495
BNP Paribas	3,866	0.0002	0.0002	0.0245	-0.1893	0.1898
Commerzbank AG	3,854	-0.0007	0.0000	0.0299	-0.2746	0.2048
Credit Suisse Group	3,833	-0.0002	0.0000	0.0252	-0.1767	0.2461
Deutsche Bank AG	3,855	-0.0002	0.0000	0.0254	-0.1754	0.2124
Dexia SA	3,866	-0.0015	0.0000	0.0673	-0.4506	0.6931
Eurazeo	3,866	0.0002	0.0000	0.0205	-0.2119	0.1190
Gam Holding Ltd	3,833	0.0001	0.0000	0.0240	-0.1657	0.1501
Groupe Bruxelles Lambert SA	3,866	0.0002	0.0003	0.0145	-0.0775	0.1064
HSBC Holdings PLC	3,844	0.0001	0.0000	0.0169	-0.2080	0.1442
ICAP PLC	3,844	0.0007	0.0000	0.0234	-0.2689	0.2048
ING Groep NV	3,866	-0.0001	0.0000	0.0309	-0.3214	0.2565
Intesa Sanpaolo SPA	3,849	0.0001	0.0000	0.0251	-0.1624	0.2162
Lloyds Banking Group PLC	3,844	-0.0003	0.0000	0.0308	-0.4147	0.4079
Man Group PLC	3,844	0.0003	0.0000	0.0277	-0.3735	0.1603
Mediobanca	3,906	0.0000	0.0000	0.0201	-0.1101	0.1533
Natixis	3,864	0.0001	0.0000	0.0272	-0.1922	0.3279
PargeSA Holding SA, Geneve	3,833	0.0001	0.0000	0.0176	-0.1294	0.1327
Royal Bank of Scotland Group PLC	3,844	-0.0006	0.0000	0.0353	-1.0957	0.3050
Schroders PLC	3,844	0.0003	0.0000	0.0241	-0.2903	0.2803
Societe Generale Group	3,866	0.0000	0.0000	0.0273	-0.1771	0.2143
Standard Chartered PLC	3,844	0.0000	0.0000	0.0235	-0.1795	0.2624
Unicredit SPA	3,849	-0.0004	0.0000	0.0265	-0.1895	0.1901
Vontobel Holding AG	3,833	0.0000	0.0000	0.0213	-0.1817	0.0983
Wendel	3,856	0.0003	0.0003	0.0245	-0.2801	0.1491
Wuestenrot & Wuernttembergi. AG	3,855	0.0001	0.0000	0.0195	-0.1353	0.1480
Insurers	Freq.	Mean	Median	St. Dev.	Min	Max
Aegon NV	3,866	-0.0004	0.0000	0.0301	-0.2768	0.3022
Ageas SA/NV	3,854	-0.0003	0.0004	0.0375	-1.4949	0.2589
Allianz SE	3,855	-0.0001	0.0001	0.0232	-0.1519	0.2331
Amlin PLC	3,836	0.0006	0.0000	0.0193	-0.3491	0.2851
Assicurazioni Generali SPA	3,848	-0.0001	0.0000	0.0173	-0.0923	0.1231
Aviva PLC	3,844	0.0000	0.0000	0.0260	-0.4060	0.2239
Axa	3,865	0.0000	0.0003	0.0272	-0.2035	0.1978
Baloise-Holding	3,833	0.0000	0.0000	0.0202	-0.1662	0.1891
CNP Assurances	3,866	0.0002	0.0000	0.0178	-0.1444	0.1043
Euler Hermes Group	3,866	0.0003	0.0000	0.0205	-0.1641	0.1463
Grupo Catalana Occidente SA	3,839	0.0007	0.0000	0.0190	-0.0871	0.1246
Hannover Rueck SE	3,854	0.0005	0.0000	0.0216	-0.1821	0.1642
Helvetia Holding AG	3,831	0.0002	0.0000	0.0208	-0.1647	0.1710
Jardine Lloyd Thompson Group PLC	3,845	0.0003	0.0000	0.0159	-0.2286	0.0861
Legal & General Group PLC	3,844	0.0003	0.0000	0.0247	-0.3408	0.2430
Mapfre	3,839	0.0003	0.0000	0.0213	-0.1344	0.1618
Munich Re	3,854	0.0000	0.0000	0.0199	-0.1704	0.1351
Novae Group	3,826	0.0000	0.0000	0.0285	-0.8230	0.3212
Nuernberger Beteiligungs AG	3,848	0.0000	0.0000	0.0180	-0.1097	0.1985
Old Mutual PLC	3,844	0.0002	0.0000	0.0255	-0.2439	0.2643
Prudential PLC	3,844	0.0002	0.0000	0.0265	-0.2231	0.2107
RSA Insurance Group Plc	3,844	-0.0002	0.0000	0.0233	-0.2426	0.1692
Sampo PLC	3,828	0.0006	0.0005	0.0177	-0.1823	0.1263
Schweizerische Rentenanstalt	3,833	-0.0002	0.0000	0.0249	-0.2241	0.1877
Scor SE	3,866	-0.0002	0.0000	0.0256	-0.3673	0.1906
St James Place	3,845	0.0003	0.0000	0.0245	-0.2328	0.2394
Unipol Gruppo Finanziario SPA	3,849	-0.0004	0.0000	0.0224	-0.1827	0.3591
UnipolSai Assicurazioni SpA	3,848	-0.0005	0.0000	0.0368	-0.8873	0.7876
UNIQA Insurance Group AG	3,798	0.0001	0.0000	0.0168	-0.1730	0.0965
Zurich Insurance Group AG	3,833	-0.0001	0.0000	0.0230	-0.2257	0.1920

Source: Compustat Global

5.2.2 Characteristics of the selected insurers

Next, insurers' characteristics were collected. First, it was checked whether insurers were identified as financial conglomerate in 2009, 2012 or 2015 by European Supervisory Authorities. The lists are available from the EBA's homepage (EBA 2016). Moreover, the sample contains five systemically important insurers classified in 2015 by the FSB (2016). *Table 4* provides information on which insurers of the sample are conglomerates or systemically important.

Regarding balance sheet items, SNL Finance provides balance sheets, income statements and investment details of the 30 insurers of my sample. Unfortunately, SNL Finance does not cover all years from 2001 to 2015. Balance sheet data is only available for the last three periods. Therefore, further analysis is only conducted for these periods. In order to test whether the potential channels identified in the first part of the thesis have an impact on the number of connections, certain balance sheet items are collected for all insurance companies. SNL converted all data to euro. *Table 4* displays the SNL Institution Keys of the sample's insurer.

Table 4: Insurers' characteristics (1)

Insurer	SNL Inst. Key	SNL Name	G-SII	EU Conglomerate
Aegon NV	113920	AEGON	Yes	Yes (2009, 2012, 2015)
Ageas SA/NV	4022946	Ageas	No	No
Allianz SE	4174043	Allianz Group	Yes	Yes (2009, 2012, 2015)
Amlin PLC	4111110	MS Amlin Plc	No	No
Assicurazioni Generali SPA	4049198	Assicurazioni Generali	No	Yes (2009, 2012, 2015)
Aviva PLC	4021316	Aviva Plc	Yes	No
Axa	4009223	AXA	Yes	Yes (2009, 2012, 2015)
Baloise-Holding	4023439	Baloise Holding	No	CHE
CNP Assurances	4175388	CNP Assurances SA	No	No
Euler Hermes Group	4145137	Euler Hermes Group	No	No
Grupo Catalana Occidente SA	4248034	Grupo Catalana Occidente	No	No
Hannover Rueck SE	4041804	Hannover Rück SE	No	No
Helvetia Holding AG	4252499	Helvetia Holding AG	No	CHE
Jardine Lloyd Thompson Group PLC	4091032	JLT	No	No
Legal & General Group PLC	4145053	Legal & General Group	No	Yes (2015)
Mapfre	4088349	MAPFRE SA	No	No
Munich Re	4005715	Münchener Rückversicherungs	No	No
Novae Group	4145133	Novae Group	No	No
Nuernberger Beteiligungs AG	4145343	NÜRNBERGER Beteiligungs-AG	No	No
Old Mutual PLC	4056128	Old Mutual Plc	No	Yes (2009, 2012, 2015)
Prudential PLC	4023122	Prudential Plc	Yes	No
RSA Insurance Group Plc	4020890	RSA Insurance	No	No
Sampo PLC	4145129	Sampo Oyj	No	Yes (2009, 2012, 2015)
Schweizerische Rentenanstalt	4144859	Swiss Life Holding	No	CHE
Scor SE	4020905	SCOR	No	No
St James Place	4145064	St. James's Place	No	Yes (2015)
Unipol Gruppo Finanziario SPA	4145340	Unipol Gruppo Finanziario	No	Yes (2012, 2015)
UnipolSai Assicurazioni SpA	4145326	UnipolSai Assicurazioni	No	No
UNIQA Insurance Group AG	4145031	UNIQA Insurance	No	Yes (2009, 2012, 2015)
Zurich Insurance Group AG	4042156	Zurich Insurance Group	No	CHE

Note: G-SIIs identified as a result of the 2015 G-SII assessment exercise (FSB 2016), Financial conglomerates as identified by the Joint Committee in 2009, 2012 and 2015 (EBA 2016 - Swiss insurers are not included)

First, in order to test whether being part of a bancassurance group increases interconnectedness, *Banking*, *Net Interest Income* and *Banking Operation Expenses* from the income statements provided by SNL Finance are collected. These balance sheet items might provide additional information to the identification as conglomerate by the Joint Committee.

With regard to the investment portfolio, holdings of banks bonds were identified as possible transmission channel. Unfortunately, SNL Finance does not provide investment in bank bonds as a separate item but it is included in the item *Corporate Bonds*. Moreover, the investment in covered bonds is not observable from the available data. Another hypothesis is that *Total Equity instruments* might increase spillovers between the banking and the insurance sector. In addition, the quality of an insurer's investment portfolio might play a role. Thus, the items *AAA-Rated Assets* and *Total Investment Grade Assets* are selected to test these hypotheses. SNL Finance also provides the item *Government Bonds and Similar* that includes government, agency, supranational and municipality bonds.

Next, it was stated that investments in derivatives might increase connectedness, and so *Total Derivative Assets and Derivate Liabilities* were selected. In addition, the *Notional Amount of Derivatives* that displays the contract value of all derivatives and *Derivatives Identified as Positive Hedges* that shows those derivatives on the asset side that are designated to hedge accounting are used. Data on investment in CDS and ART is not available. Moreover, the items *Unit-Linked Investments* and *Unit-Linked Insurance and Investment Contracts* show those assets and liabilities that are reported separately. For those items, the policyholder gains the income and bears the risk. It should be noted that from the available data it is not observable whether the products in those accounts involve guarantees.

With regard to funding, SNL Finance makes no data on short-term funding available. However, non-policyholder liabilities are proxied by *Total Financial Liabilities* and *Total Other Liabilities*. Alternatively, Total Financial liabilities alone are used as a proxy for non-policyholder liabilities. Financial liabilities are total liabilities excluding liabilities linked to the insurance business such as reserves and insurance and reinsurance payables. Total other liabilities may contain any liabilities not otherwise classified.

With regard to the number of observations, not all items are available for all insurers. Especially, in the case of banking income and banking expenses less than 10 observations are available in all periods. However, five out of the seven firms that report at least one of those items were classified as EU conglomerates by the Joint Committee. I will therefore use the classification as a conglomerate instead of banking income and expenses to determine whether having ownership ties with banks influences the interconnectedness of an insurer.

The absolute size of some items such as government bonds might simple reflect the absolute size of the balance sheet of an insurer. Therefore, ratios are used during further analysis. Items on the liability side are compared to total liabilities. Corporate bonds, Government bonds, derivate and equity investment are divided by investment excluding unit-linked investment because the four balance sheet items only contain non-unit linked investments. High quality assets are compared to total assets bearing credit risks. Finally, derivatives designated to hedge accounting are compared to total derivative assets in order to obtain the proportion of derivatives used for hedging purposes.

Table 5 provides summary statistics of total assets and the calculated ratios over the three periods. To calculate the ratios the means of the relevant balance sheet items over three years were used. Some hypothesis cannot be tested because there is not data available. SNL Finance does not provide data on investment in bank bonds, CDS, ART and the maturity of the insurer's financing.

Table 5: Insurers' characteristics (2)

Item (Mio. Euro)	2007 - 2009					2010 - 2012					2013 - 2014				
	Freq	Mean	SD	Max	Min	Freq	Mean	SD	Max	Min	Freq	Mean	SD	Max	Min
Total Assets	30	167,784	215,864	866,622	1,145	30	169,907	202,380	740,152	1,652	30	197,552	234,069	827,527	2,566
Ratio	Freq	Mean	SD	Max	Min	Freq	Mean	SD	Max	Min	Freq	Mean	SD	Max	Min
AAA-Rated Assets / Total Assets Bearing Credit Risk	24	0.40	0.14	0.68	0.05	23	0.33	0.12	0.55	0.03	26	0.22	0.12	0.46	0.02
Corporate Bonds / Invest. Excl. Unit-Linked	11	0.25	0.09	0.39	0.10	15	0.29	0.11	0.50	0.06	20	0.28	0.09	0.40	0.06
Derivative Liabilities / Total Liabilities	24	0.01	0.01	0.05	0.00	25	0.01	0.01	0.04	0.00	27	0.01	0.01	0.04	0.00
Derivatives Identified as Pos. Hedges / Total Deriv. Assets	9	0.36	0.38	1.00	0.02	13	0.29	0.34	1.00	0.00	13	0.30	0.30	1.00	0.03
Gov't Bonds and Similar / Invest. Excl. Unit-Linked	15	0.28	0.09	0.39	0.09	19	0.30	0.13	0.60	0.06	24	0.32	0.14	0.60	0.09
Non-Insurance liabilities/ Total Liabilities	30	0.18	0.16	0.76	0.04	29	0.16	0.12	0.53	0.04	28	0.15	0.12	0.60	0.06
Notional Amount of Derivatives / Total Assets	13	0.20	0.15	0.43	0.01	12	0.23	0.18	0.59	0.03	14	0.22	0.17	0.52	0.01
Total Derivative Assets / Invest. Excl. Unit-Linked	23	0.02	0.04	0.18	0.00	24	0.03	0.09	0.46	0.00	25	0.04	0.12	0.61	0.00
Total Equity Instruments / Invest. Excl. Unit-Linked	26	0.12	0.11	0.55	0.02	25	0.09	0.10	0.47	0.00	28	0.10	0.11	0.59	0.00
Total Financial Liabilities / Total Liabilities	30	0.11	0.13	0.69	0.01	29	0.09	0.07	0.36	0.01	29	0.09	0.08	0.35	0.02
Total Invest. Grade Assets / Total Assets Bear. Credit Risk	22	0.85	0.21	1.00	0.07	21	0.84	0.21	0.98	0.05	24	0.84	0.20	0.99	0.03
Unit-Linked Investments / Total Assets	22	0.19	0.22	0.81	0.00	21	0.21	0.22	0.85	0.02	22	0.23	0.22	0.87	0.03
Unit-Linked Liabilities / Total Liabilities	21	0.23	0.24	0.91	0.02	21	0.24	0.22	0.83	0.03	22	0.25	0.20	0.76	0.03

Note: The table displays summary statistics for *Total Assets* and the ratios of the 30 insurers of the sample for each period. Frequency shows for how many firms data for the item is available. *Total Assets* refer to the mean over the three years of each period. Ratios refer to the ratios of averages of each balance sheet item over three years.

Considering the average size of insurers over the three periods, Allianz and AXA are the largest insurers with average assets exceeding 700 billion. On the other hand, Jardine Lloyd Thompson Group PLC and Novae Group are the smallest insurers of the sample and have less than 3 billion of average assets. Although insurers were selected based on their size, balance sheet assets of the sample's insurer vary considerably.

Table 5 shows that the most important investment class over all periods are government bonds followed by corporate bonds. On average, insurers of my sample invest around 30% of their portfolio in sovereign debt. Total equity instruments make up only around 10%. The composition of the investment portfolios of my sample seems to correspond to the average composition of portfolios of European insurers (EIOPA 2016). While the share of equity was slightly decreasing over the three periods, government debt was increasing. However, there are some insurers that have invested more than 20% in equity. The highest proportion is reported by St. James Palace. As this firm has a very high proportion of unit-linked investments, investment excluding unit-linked investment accounts only for a small proportion of its balance sheet. Compared to total assets, St. James Palace's investment in equity is very low.

Turning to unit-linked investments, it can be observed that separate accounts make up on average 20% of the insurers' balance sheets and that there was a slight increase over the last years. This corresponds to the increased importance of unit-linked products in Europe. On the liability side, unit-linked contracts show the same development. The number of separate accounts seems to vary substantially among insurers. For example, two British insurance companies, Legal & General Group and St. James Place, report up to 87% of total assets to be unit-linked. On the other hand, there are firms such as the Spanish insurers Mapfre and Grupo Catalana Occidente that report less than 5%.

With regard to the quality of the 30 insurers' investments, it can be observed that investment grade assets make up about 84% to 85% of total assets bearing credit risk. This shows insurers preferences for high quality assets. However, the share of triple A rated assets seems to have decreased from the first to the most recent period. The minimum ratio of total investment grade assets is reported St. James Place that has a much higher proportion of not rated assets than the other insurance companies.

Next, derivatives are seen as having the potential to increase the interconnectedness of the insurance sector. However, looking at my sample, the proportion of derivative assets varies

between 2% and 4% of investments and on average, only 1% of liabilities is made up by derivatives. Again, insurers that have a high proportion of unit-linked investments represent outliers. The proportion of derivative assets designated to hedge accounting varies among insurers. While one insurer only invests in derivatives for hedging purposes, there are other with very low hedging ratios.

Finally, non-policyholder funding made up by total financial liabilities and other liabilities accounts for 18% to 15% of total liabilities. It seems that non-policyholder funding is slightly decreasing. The highest ratio of non-policyholder funding is reported by Ageas during the first period. Financial liabilities of Ageas drop substantially from 2007 to 2009. The reason might be that in 2008 the banking and insurance business of the former Fortis bank was fully separated and Ageas became a pure insurance company (Reuters 2010).

The balance sheet data of the 30 insurers points towards changes over the last years and to differences in the business models of individual insurers. Those different characteristics might lead to different levels of connectedness to the banking sector. The next section will therefore examine which characteristics are related to the linkages an insurer has to the banking sector

6 Empirical results

6.1 Granger causality test

6.1.1 Granger causality test based on monthly data

First, the Granger causality measure was calculated with monthly data. An augmented Dickey-Fuller test was run for one up to six lags and confirmed that the returns series of each firm are stationary. Next, heteroscedasticity was filtered out using a GARCH(1,1) model². Then pairwise VAR models that model stock returns as dependent on lagged values of itself and on lags of the return series of another firm were set up. *Table 6* displays the number of lags selected by AIC. The Granger causality test was conducted for a maximum lag of 6 months. In most of the cases where AIC did suggest to include lags, one month was selected as optimal lag length. In five cases, the VAR model for a pair of institutions was found to be unstable. Those pairs were excluded. Autocorrelation in the residuals was tested with a maximum order of six. Autocorrelation was found only in 2% to 3% of tests run. *Table 7* displays further details.

Table 6: VAR models - Number of lags selected by AIC

2001 2003			2004 2006			2007 2009			2010 2012			2013 2015		
lags	No.		lags	No.		lags	No.		lags	No.		lags	No.	
0	3120	86.67%	0	3051	84.75%	0	2324	64.56%	0	2796	77.67%	0	3187	88.53%
1	236	6.56%	1	164	4.56%	1	249	6.92%	1	534	14.83%	1	243	6.75%
2	78	2.17%	2	138	3.83%	2	166	4.61%	2	132	3.67%	2	75	2.08%
3	40	1.11%	3	98	2.72%	3	142	3.94%	3	37	1.03%	3	37	1.03%
4	27	0.75%	4	64	1.78%	4	386	10.72%	4	36	1.00%	4	18	0.50%
5	57	1.58%	5	42	1.17%	5	140	3.89%	5	41	1.14%	5	16	0.44%
6	42	1.17%	6	43	1.19%	6	193	5.36%	6	24	0.67%	6	24	0.67%
Sum	3600		Sum	3600		Sum	3600		Sum	3600		Sum	3600	

Note: The maximum lag was set to 6 months

Table 7: VAR models - LM test for autocorrelation in the residuals

	2001 2003		2004 2006		2007 2009		2010 2012		2013 2015	
	No.	%	No.	%	No.	%	No.	%	No.	%
No residual autocorrelation	64	2%	84	3%	244	3%	94	2%	40	2%
Residual autocorrelation	2816	98%	3210	97%	7412	97%	4730	98%	2438	98%
Sum of tests	2880	100%	3294	100%	7656	100%	4824	100%	2478	100%
Total pairs tested*	480		549		1276		804		413	

Note: The maximum order of autocorrelation to tested was 6

*Pairs for which AIC did suggest the inclusion of lags

² In case of monthly returns, in two cases GARCH (1,2) and in one case a GARCH (2,2) was used because the statistical software STATA was not able to fit a GARCH (1,1) model or because the ARCH effect was still present after using the GARCH (1,1) model

Table 8 illustrates the number of Granger causal connections between the 30 banks and insurers. It presents the number of those connections that are significant at the 5% level. On the top, the leading industry is displayed while on the left the industry that receives shocks is shown. The sum of all connections includes inter- as well as intra-industry connections. The table shows that the overall number of connections between the institutions of my sample changed significantly over the five periods. The first period between 2001 and 2003 seems relatively tranquil while in the pre-crisis period of 2004 to 2006 connections already start to increase indicating the run up of the crisis. Comparing the first two periods, connections increase slightly in the period of the introduction of Solvency I and Basel II. Total connections peak between 2007 and 2009. This period encompasses the failure of Lehman Brothers and the bail out of AIG. After the crisis, the total number of connections decreases again although it does not reach its pre-crisis level before the last period between 2013 and 2015.

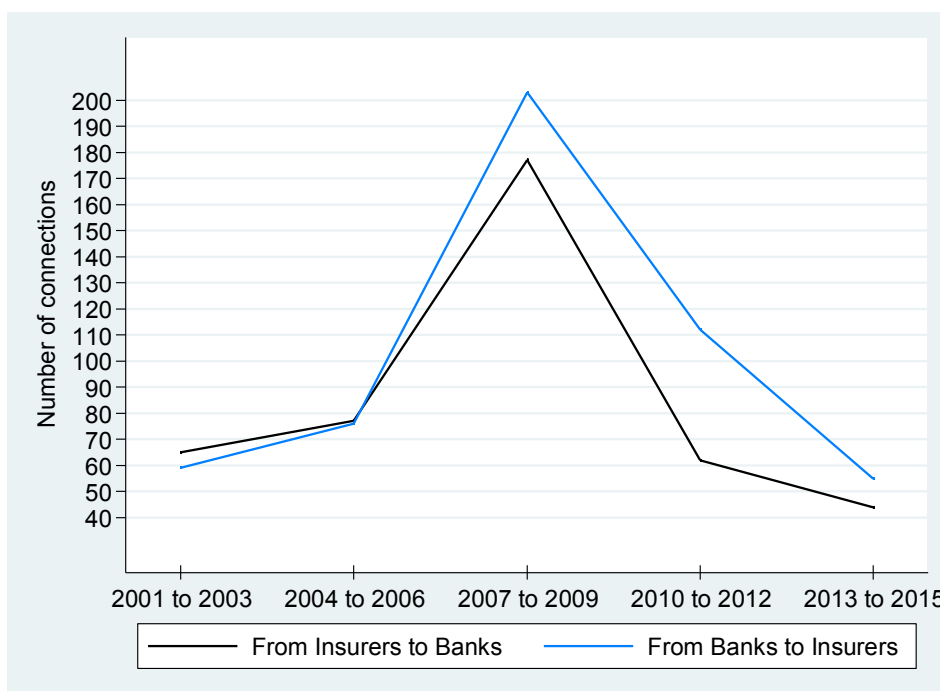
Table 8: Granger connections between banks and insurers

		Number of connections			% of possible connections		
		<i>from</i>			<i>from</i>		
	<i>to</i>	Banks	Insurers	All	Banks	Insurers	All
		2001 2003					
	Banks	54	65		6.21%	7.22%	
	Insurers	59	52	230	6.56%	5.98%	6.50%
		2004 2006					
	Banks	86	77		9.89%	8.56%	
	Insurers	76	43	282	8.44%	4.94%	7.97%
		2007 2009					
	Banks	218	177		25.06%	19.67%	
	Insurers	203	182	780	22.56%	20.92%	22.03%
		2010 2012					
	Banks	59	62		6.78%	6.89%	
	Insurers	112	81	314	12.44%	9.31%	8.87%
		2013 2015					
	Banks	34	44		3.91%	4.89%	
	Insurers	55	53	186	6.11%	6.09%	5.25%

Note: Granger causality relationships from insurers to banks and vice versa significant at 5% level. Heteroscedasticity was filtered out with a GRACH model following Billio et al. (2012).

Next, the table also shows how the directionality of connections changed over time. During the first period, insurers seem to lead banks as there are 65 connections from insurers to banks. One possible explanation could be that equity sells of insurer during this period hit the banking sector (See *Section 4.1.2*). However, the number of 59 connections in the opposite direction is not much lower. In addition, the number of connections among insurers of 52 is not much higher than during other periods. This indicates limited effects of the equity crisis in the insurance sector on the number of connections. In the following period, both sectors seem to influence each other almost equally. This changes during the financial crisis from 2007 to 2009. Now, there are 203 connections from banks to insurer and only 177 in the other direction. This seems to confirm the observation that the crisis was mainly a banking crisis that hit the insurance sector. Even though total connections in both directions decrease after the crisis, the dominance of the banking sector in leading the insurance sector continues. Indeed, from 2010 to 2012 there are 112 linkages from banks to insurer and only slightly more than half of this number in the other directions. The sovereign debt crisis intensified during this period starting with the bail-out of Greece that took place in May 2010 (Wearden 2010). Insurers keep playing a subordinated role during the last period from 2013 to 2015. These developments are illustrated by *Figure 1*.

Figure 1: Sum of Granger connections between banks and insurers



Finally, connections for each firm are displayed by *Table 9*. For each insurer, connections to banks and connections from banks as well as the overall sum of inter-sector connections are shown. Each insurer can have a maximum of 30 outgoing and 30 incoming connections to the sample of 30 banking firms. This means a maximum of 60 connections is possible for each insurer. The purpose of this table is to compare the connectedness of individual insurers relative to each other.

The median of overall connections to the banking sector by firm varies from 2.5 in the most recent period to 14.5 during the financial crisis. In each period, there are some insurers that do not seem to be influenced by or to influence the banking sector as there are always firms that have zero connections. The group of independent insurers seems to change each period. Also, those firms with the highest relative interconnectedness change each period. During the first two periods two Spanish insurers have the highest number of linkages to the banking sector. During the crisis, the British Legal & General Group has the highest number of linkages. During this period the second largest insurance company of the sample AXA is very strongly influenced by the banking sector. During the last two periods a French Property & Casualty insurer and a British insurance broker show the most linkages. In the period from 2010 to 2012, the median of incoming connections is slightly lower than the median of outgoing connections. This indicates that the much higher sum of incoming connections of all insurers is caused by some individual firms that are highly influenced by the banking sector.

To sum up, the degree of interconnectedness of my sample insurers to the sample of banks is varying relative to each other and over time. The next step will therefore be to examine whether those different degrees of connectedness could be explained by different characteristics of the individual insurers.

Table 9: Granger connections per insurer

	2001 2003			2004 2006			2007 2009			2010 2012			2013 2015		
Insurer	From banks	To banks	Total	From banks	To banks	Total	From banks	To banks	Total	From banks	To banks	Total	From banks	To banks	Total
Aegon NV	1	1	2	1	0	1	7	12	19	0	2	2	1	2	3
Ageas SA/NV	1	0	1	2	5	7	5	10	15	0	1	1	5	2	7
Allianz SE	0	2	2	3	2	5	8	10	18	2	1	3	1	3	4
Amlin PLC	0	0	0	2	5	7	13	6	19	1	3	4	9	1	10
Assicurazioni Generali SPA	0	0	0	3	6	9	12	6	18	0	0	0	1	2	3
Aviva PLC	0	0	0	4	3	7	11	4	15	5	0	5	0	0	0
Axa	2	2	4	1	1	2	16	5	21	1	2	3	0	1	1
Baloise-Holding	2	6	8	0	0	0	5	7	12	0	0	0	0	3	3
CNP Assurances	3	2	5	2	1	3	14	5	19	1	0	1	0	0	0
Euler Hermes Group	1	5	6	5	3	8	9	14	23	20	9	29	1	1	2
Grupo Catalana Occidente SA	4	4	8	7	11	18	7	7	14	9	5	14	0	1	1
Hannover Rueck SE	4	3	7	0	1	1	2	3	5	1	1	2	0	0	0
Helvetia Holding AG	3	1	4	1	1	2	4	0	4	2	1	3	0	0	0
Jardine Lloyd Thompson PLC	5	4	9	2	6	8	0	0	0	1	2	3	12	11	23
Legal & General Group PLC	0	0	0	1	2	3	12	14	26	10	8	18	3	1	4
Mapfre	11	3	14	3	2	5	8	1	9	1	0	1	2	2	4
Munich Re	1	2	3	1	1	2	8	5	13	0	0	0	0	0	0
Novae Group	0	5	5	0	0	0	0	1	1	10	1	11	5	0	5
Nuernberger Beteiligungs AG	3	1	4	3	5	8	6	11	17	8	0	8	1	0	1
Old Mutual PLC	0	2	2	0	1	1	2	4	6	1	2	3	1	1	2
Prudential PLC	1	1	2	8	4	12	11	12	23	10	3	13	3	0	3
RSA Insurance Group Plc	2	2	4	4	2	6	1	1	2	3	2	5	1	2	3
Sampo PLC	1	1	2	1	1	2	8	3	11	1	0	1	0	1	1
Schweizerische Rentenanstalt	3	7	10	4	0	4	1	14	15	0	1	1	2	3	5
Scor SE	1	0	1	1	0	1	9	9	18	3	2	5	1	1	2
St James Place	3	0	3	8	5	13	1	0	1	6	5	11	2	1	3
Unipol Gruppo Finanziario SPA	0	0	0	2	5	7	7	2	9	2	3	5	0	0	0
UnipolSai Assicurazioni SpA	0	0	0	3	2	5	6	3	9	0	0	0	2	0	2
UNIQA Insurance Group AG	1	4	5	1	0	1	0	1	1	14	5	19	2	4	6
Zurich Insurance Group AG	6	7	13	3	2	5	10	7	17	0	3	3	0	1	1
Sum	59	65	124	76	77	153	203	177	380	112	62	174	55	44	99
Median	1	2	3.5	2	2	5	7	5	14.5	1	1.5	3	1	1	2.5
Min	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Max	11	7	14	8	11	18	16	14	26	20	9	29	12	11	23

6.1.2 Granger causality test based on daily data

Initially, the Granger causality measure was also calculated based on daily data. However, daily data posed several challenges. Due to technical restrictions, I was only able to use a maximum of 10 days because longer periods significantly slowed down the statistical software STATA that was used to conduct the analysis of this paper. However, a maximum of 30 days was tested for two periods and did not produce very different results. Moreover, the results obtained when using daily data do not seem robust because during the financial crisis period from 2007 to 2009 the total number of connections between banks and insurers is much lower than from 2001 to 2003 and the following period. This finding contradicts the findings of Billio et al. (2012) for the U.S. financial sector and the findings of Berdin and Sottocornola (2015) for the European financial sector. Both use monthly data and find the maximum number of connections during the period of the financial crisis. In addition, as firms from different European countries are included into the sample, stocks could be traded at different hours and national holidays can differ. This might lead to bias due to the “nonsynchronous trading effect” (Lo and MacKinlay 1990). If one stock is traded less frequently than the other, results could be biased. This is because information arriving near the closing hour is reflected in the closing price of one security while it is not included in the price of another stock until the next day. Different trading hours can also lead to non-synchronous trading (Peiró 2016). Such an effect could look like a lead-lag relationship and might lead to misleading results when applying the Granger causality measure. Due to the problems encountered when using daily data, I will rely on monthly data for the following analysis.

6.2 Characteristics of insurers and interconnectedness

6.2.1 Differences in median of interconnections

After having determined the relative interconnectedness of the insurers of my sample, I will now analyze possible reasons for the different degrees of interconnectedness. First, it will be analyzed whether the type of the insurer and being a conglomerate changes its interconnectedness. In addition, it is tested whether there is a difference between UK and non-UK insurance. Finally, it will also be tested whether global systemically important insurers have a higher degree of interconnectedness.

Table 10: Differences in connections between different groups of insurers

Comparison of mean connections across groups				Kruskal-Wallis equality-of- populations rank test		
Subsector	Freq.	Median (in)	Median (out)	K-W test	In	Out
2007 2009						
Insurance Brokers	1	0	0	chi-squared	2.668	4.521
Life & Health Insurance	7	7	12	p	0.6148	0.3401
Multi-line Insurance	15	7	5			
Property & Casualty Insurance	4	5	3.5			
Reinsurance	3	8	5			
2010 2012						
Insurance Brokers	1	1	2	chi-squared	3.435	5.063
Life & Health Insurance	7	1	2	p	0.4879	0.2809
Multi-line Insurance	15	1	1			
Property & Casualty Insurance	4	6.5	2.5			
Reinsurance	3	1	1			
2013 2015						
Insurance Brokers	1	12	11	chi-squared	9.795	4.912
Life & Health Insurance	7	2	1	p	0.044	0.2965
Multi-line Insurance	15	0	1			
Property & Casualty Insurance	4	3	1			
Reinsurance	3	0	0			
GSIs	Freq.	Median (in)	Median (out)	K-W test	In	Out
2013 2015						
Others	25	1	1	chi-squared	0.27	0.003
GSIs	5	1	1	p	0.603	0.9537
EU conglomerate	Freq.	Median (in)	Median (out)	K-W test	In	Out
2007 2009						
Others	19	7	5	chi-squared	0.102	0.084
Conglomerate	7	8	5	p	0.7495	0.7716
2010 2012						
Others	18	3	1.5	chi-squared	1.219	0.003
Conglomerate	8	1	2	p	0.2695	0.9546
2013 2015						
Others	16	1	0.5	chi-squared	0.5	2.93
Conglomerate	10	1	1	p	0.4794	0.087
UK insurer	Freq.	Median (in)	Median (out)	K-W test	In	Out
2007 2009						
Non UK insurer	21	7	6	chi-squared	0.433	1.449
UK insurer	9	2	4	p	0.5104	0.2286
2010 2012						
Non UK insurer	21	1	1	chi-squared	4.222	2.858
UK insurer	9	5	2	p	0.0399	0.0909
2013 2015						
Non UK insurer	21	1	1	chi-squared	7.175	0.142
UK insurer	9	3	1	p	0.0074	0.706

Note: Median (in) refers to incoming connections from the banking sector and Median (out) refers to outgoing connections to the banking sector. P-values below 1%, 5% and 10% level are in bold.

Table 10 summarizes medians of groups based on different characteristics. The table displays medians of incoming connections from the banking sector and outgoing connections to the banking sector. The results of the Kruskal-Wallis test for significance of difference between the groups are displayed on the right side. The Shapiro–Wilk normality test was applied to test whether the number of connections per firm is normally distributed. The null hypothesis that incoming and outgoing connections are normally distributed is rejected in the last two periods. Therefore, a non-parametric method is used to determine whether there are significant differences among groups.

First, the type of insurer is investigated. In total, there are five different types of insurers. Half of the insurers are classified as multi-line insurer which are active in life as well as non-life insurance. There are three reinsurers and the British Jardine Lloyd Thompson Group is the only insurance broker. The median of connections to the banking sector varies among different subsectors. Moreover, there is no subsector that seems to be dominant over all three periods. During the crisis period, life insurers followed by multi-line insurers seem to have the highest median of incoming as well as outgoing connections to the banking sector. In case of life insurers, the median of outgoing connections even exceeds the median of incoming connections. P&C insurers seem less affected than the other groups. This corresponds to Baluch, Mutenga and Parsons (2011) who find that life insurers were the worst performing group during the financial crisis. However, this observation does not hold for the periods from 2010 to 2012 and 2013 to 2015. During these periods, non-life insurers are driven more strongly by the banking sector than other groups of insurers except the insurance broker. The Kruskal-Wallis test only indicates a significant difference between subsectors from 2013 to 2015 with regard to incoming connections from the banking sector. However, if the Kruskal-Wallis test is conducted without the insurance broker, the p-value increases to 0.0630 and exceeds the significance level of 5%.

Second, the median of the group of insurers identified as global systemically important was compared to that of other insurers. The comparison is only made for the last period as G-IIS were identified for the first time during this period (FSB 2016). Five out of the 30 insurers of my sample were identified as G-IIS in 2015 (FSB 2016). An important criterion to identify G-IIS was interconnectedness measured by indicators such as intra-financial assets and liabilities or derivatives (IAIS 2013). Nevertheless, interconnectedness of G-IIS is equal to other insurers. In addition, the Kruskal-Wallis test does not indicate any significant differences between the two groups. The G-IIS would not have been identified based on the measure of risk applied to the sample of this thesis.

Third, it was investigated whether conglomerates identified by the Joint Committee tend to have more connections to the banking sector. The number of insurers identified as conglomerates increases slightly over the three periods. Again, the median of connections varies between conglomerates and non-conglomerates and the dominant group changes over the different time periods. During the crisis period, banks seem to influence conglomerates slightly more than non-conglomerates. The influence of insurers on banks seems equal for both groups. However, after the crisis, banks suddenly have a stronger impact on non-conglomerates. This result seems counterintuitive. Finally, during the last period, banks have equal influence on both conglomerates and non-conglomerates. The impact of conglomerates on banks is slightly higher than that of non-conglomerates. The last difference is significant at the 10% level. However, the Kruskal-Wallis test does not indicate any other significant differences between conglomerates and non-conglomerates.

Finally, the median of connections is compared between UK and non-UK insurers. According to Baluch, Mutenga, & Parsons (2011), cross-holding between banks and insurers are less important in the UK than in other parts of Europe and thus, interconnections of non-UK insurers should be higher. Indeed, during the period from 2007 to 2009 the median of Granger connections of the UK group is lower than that of the non-UK group. This is true for outgoing and incoming connections. However, this tendency is reversed in the periods after the financial crisis. From 2010 to 2015 UK insurers have higher medians of linkages to the banking sector, especially with regard to outgoing connections. Baluch, Mutenga, & Parsons (2011) do not investigate these periods. The Kruskal-Wallis test does not find significant differences between the two groups during the financial crisis. However, it finds significant differences regarding incoming connections during the last two periods.

The findings with regard to conglomerates and UK insurers indicate that bancassurance might have led to higher interconnectedness during the crisis. However, the comparison of medians does not indicate that this effect persists after the crisis. Moreover, differences between the groups were not found to be significant during the crisis period. The null hypothesis that being a conglomerate does not influence interconnectedness is therefore not rejected.

6.2.2 Correlation of interconnectedness and balance sheet items

The next step is to investigate different balance sheet items of the insurers. *Table 11* displays the results of the Spearman rank correlation for the three periods between Granger connections and balance sheet items of the sample's insurer.

Table 11: Spearman's rank correlation coefficient

Items	2007 2009			2010 2012			2013 2015		
	Incoming connections	Outgoing connections	Total connections	Incoming connections	Outgoing connections	Total connections	Incoming connections	Outgoing connections	Total connections
Incoming connections	1			1			1		
Outgoing connections	0.4560** (0.0113)	1		0.5161*** (0.0035)	1		0.3308* (0.0742)	1	0 (0)
Total connections	0.8352*** (0)	0.8365*** (0)	1	0.9199*** (0)	0.7531*** (0)	1	0.8719*** (0)	0.7007*** (0)	1 (0)
Total assets	0.5189** (0.0033)	0.3207* (0.084)	0.5068** (0.0043)	-0.1905 (0.3132)	-0.0859 (0.6519)	-0.1674 (0.3766)	-0.2483 (0.1858)	-0.0941 (0.6211)	-0.2009 (0.2872)
A.A.A.-Rated Assets / Total Assets Bearing Credit Risk	0.2263 (0.2876)	0.3159 (0.1327)	0.2685 (0.2046)	0.0111 (0.96)	-0.2342 (0.2821)	-0.0275 (0.901)	-0.2027 (0.3206)	-0.2809 (0.1645)	-0.203 (0.32)
Corporate Bonds / Invest. Excl. Unit-Linked	0.0592 (0.8627)	0.0732 (0.8306)	-0.0365 (0.9151)	-0.2764 (0.3187)	-0.4204 (0.1187)	-0.3622 (0.1846)	-0.065 (0.7853)	0.0344 (0.8854)	0.0114 (0.9618)
Derivative Liabilities / Total Liabilities	0.1654 (0.4398)	0.1653 (0.4401)	0.2255 (0.2895)	-0.1574 (0.4525)	0.0244 (0.9077)	-0.1005 (0.6326)	0.2604 (0.1895)	0.0901 (0.6548)	0.1976 (0.3232)
Derivatives Identified as Pos. Hedges / Total Deriv. Assets	-0.3755 (0.3193)	-0.7511** (0.0197)	-0.5607 (0.1163)	0.3587 (0.2288)	0.4691 (0.1059)	0.5141* (0.0723)	0.6912*** (0.0089)	0.3273 (0.2749)	0.6472** (0.0168)
Gov't Bonds and Similar / Invest. Excl. Unit-Linked	0.0628 (0.8241)	-0.5941** (0.0195)	-0.1091 (0.6987)	-0.4128* (0.079)	-0.2301 (0.3433)	-0.3274 (0.1712)	-0.1601 (0.455)	0.1381 (0.52)	-0.0159 (0.9412)
Non-Insurance liabilities/ Total Liabilities	-0.0286 (0.8809)	0.0272 (0.8864)	-0.0314 (0.869)	-0.1992 (0.3002)	0.088 (0.6497)	-0.1404 (0.4676)	-0.0371 (0.8515)	0.4650** (0.0127)	0.1269 (0.5199)
Notional Amount of Derivatives / Total Assets	0.2039 (0.5041)	0.1134 (0.7122)	0.1486 (0.6281)	-0.0586 (0.8565)	0.0763 (0.8137)	0.0072 (0.9823)	-0.1346 (0.6464)	0.0907 (0.7577)	0.0292 (0.9211)
Total Derivative Assets / Invest. Excl. Unit-Linked	0.1523 (0.4878)	0.2823 (0.1918)	0.3082 (0.1525)	-0.3089 (0.1419)	-0.1813 (0.3966)	-0.2156 (0.3116)	0.1665 (0.4264)	0.0749 (0.7219)	0.1403 (0.5036)
Total Equity Instruments / Invest. Excl. Unit-Linked	0.1901 (0.3522)	0.0069 (0.9734)	0.121 (0.5559)	0.2444 (0.239)	-0.0016 (0.994)	0.1671 (0.4246)	0.01 (0.9597)	-0.1688 (0.3906)	-0.0338 (0.8642)
Total Financial Liabilities / Total Liabilities	0.1056 (0.5788)	0.0161 (0.9328)	0.0569 (0.7653)	-0.1556 (0.4201)	0.1333 (0.4905)	-0.0716 (0.7122)	0.0854 (0.6596)	0.3930** (0.035)	0.2221 (0.2469)
Total Invest. Grade Assets / Total Assets Bear. Credit Risk	0.2112 (0.3454)	0.2132 (0.3409)	0.2065 (0.3565)	-0.1038 (0.6544)	-0.1592 (0.4905)	-0.1672 (0.4689)	-0.1679 (0.4329)	0.18 (0.3999)	-0.0233 (0.9139)
Unit-Linked Investments / Total Assets	0.0925 (0.6821)	0.2001 (0.3719)	0.268 (0.2279)	0.0711 (0.7593)	0.319 (0.1588)	0.3258 (0.1495)	0.3706* (0.0895)	0.0675 (0.7653)	0.264 (0.2352)
Unit-Linked Liabilities / Total Liabilities	0.0967 (0.6768)	0.0867 (0.7085)	0.224 (0.3289)	0.0767 (0.7411)	0.3906* (0.08)	0.3495 (0.1204)	0.305 (0.1675)	0.0035 (0.9876)	0.1818 (0.418)

Note: Significance level is shown in parentheses. ***, **, * denote significance at the 1%, 5% and 10% level

There are only few balance sheet items for which significant rank correlation is found. Moreover, items that seem to correlate with linkages to the banking sector change each period. During the period from 2007 to 2009 four correlation coefficients are significant at the 5% level. In the period from 2010 to 2012 no correlation coefficient is significant at the 5% level. If the significance level is increased to 10%, three coefficients become significant. In the last period four items are found to be significantly correlated with interconnections.

First, the size of an insurer is significantly correlated with linkages to the banking sector during the period of the financial crisis. During this period, larger insurers are affected more strongly by banks than smaller insurers. At a significance level of 10%, there is also significant correlation between total assets and connections from insurers to banks. This finding is interesting as size is not regarded as important for the systemic risk of insurers. The higher interlinkage of larger insurers with the banking sector during the crisis contradicts this assumption. However, total assets are not correlated with the number of connections during the other two periods.

With regard to balance sheet items, equity investment and investment quality do not seem to have any significant impact on the interlinkages between banks and insurers.

Moreover, government bonds have a significant correlation with interlinkages during the periods of the financial and the sovereign debt crisis. During the period from 2007 to 2009, investments in sovereign bonds correlated with the influence insurers have on banks. During the next period, government bonds correlate with influence coming from the banking sector. In the second period, the coefficient is only significant at the 10% level. In both cases the correlation coefficient has a negative sign indicating that a higher proportion of government investment makes an insurer more stable and less interlinked with the banking sector. The signs of the coefficients seem surprising because especially the periods of the financial and sovereign debt crisis are characterized by higher sovereign risk linked to banks bail outs (Acharya, Drechsler and Schnabl 2014). Thus, positive coefficients would have been expected. Nevertheless, it cannot be observed which countries have issued the sovereign debt held by the insurers of my sample. Spillovers between banks and insurers through this channels are triggered if banks and insurers hold bonds of the same sovereign or if the country that issued the bonds bailed out a bank. Nevertheless, the null hypothesis that an insurer's investment in sovereign debt is not correlated the number of connections to banks can be rejected at least for two periods.

Next, with regard to derivatives, derivative assets and liabilities and the notional amount of derivatives do not seem to correlate with neither incoming nor outgoing connections. However, during the crisis from 2007 to 2009, the proportion of derivatives designated to hedge accounting seems to be negatively correlated with outgoing connections. Insurers that used their derivatives for hedging purposes seem to have exerted less influence on the banking sector than other insurers during this period. This might point to possible consequences of the non-traditional use of derivatives by insurers. However, during the last period, the Spearman correlation coefficient of derivatives used for hedging and incoming connections is found to be negative and significant. This result seems counter-intuitive. Therefore, there is not conclusive evidence for the hypothesis that an insurer's investment in derivatives decreases the number of connections to banks.

Turning to separate accounts on the asset and liability side, a significant and positive relationship was found during two periods. During the sovereign debt crisis, separate accounts on the liability side have correlated with the influence insurers have on banks. In the period from 2013 to 2015, correlation is found between separate accounts on the assets side and incoming connections. Thus, there is some evidence for the hypothesis that separate accounts of an insurer influence the number of connections to banks. The offering of non-traditional products such as variable annuities that are held in such accounts seems to have the potential to increase linkages to the banking sector.

Finally, during the last period the coefficient of financial liabilities and outgoing connections was found to be significant. The same is true for non-insurance liabilities that consist of financial liabilities and other liabilities. Insurers that rely more on non-policyholder funding seem to have more influence on the banking sector relative to other insurers. However, this effect is only found in the last period. Therefore, evidence supporting the hypothesis that non-policyholder liabilities of an insurer influence the number of connections to banks is only weak.

Comparison of the means among groups and the Spearman Rank correlation coefficient indicated some significant relationships between the characteristics of an insurer and its links to the banking sector. However, no item seems to be important for the interconnectedness of an insurer over all periods investigated. As only few items are found to be significantly correlated with the number of Granger connections and some balance sheet items are not available for all insurers of the sample, no further regression analysis is undertaken.

7 Limitations

The analysis of insurers' characteristics and their interconnectedness to the banking sector conducted in this thesis has several limitations.

First, data availability was an issue. For some insurers, only few balance sheet items were available. If complete balance sheet data of all firms was available, results might have been more conclusive. Also, more detailed data could improve the analysis. For example, the maturity of liabilities could provide additional information on how funding of insurers influences their relationship to the banking sector. It is also not observable whether separate accounts of insurers include products with a guaranteed return. Moreover, the type of derivatives an insurer holds and issues would be of interest to examine whether the insurer is engaged in risk transfer to and from the banking sector. Obtaining data on the countries that issued the debt held by the insurers of the sample would bring additional insight on why it was found that sovereign debt had a stabilizing function during the sovereign debt crisis.

In addition, it has to be stressed that the results of the Granger causality measure only display the relations among the institutions of the sample. The results thus have to be interpreted with care. Changing the sample could lead to different results with regard to the interconnectedness of banks and insurers. Moreover, increasing the sample size would provide a broader picture of the European banking and insurance sector and enable a more detailed statistical analysis.

Finally, it might be worth applying alternative measures of connectedness. For example, Billio et al. (2012) propose a non-linear Granger causality test. The linear Granger causality measure used in this thesis was not able to identify globally significant insurers of my sample although an important criterion for selecting these insurers is interconnectedness. Also with regard to other characteristics, findings are limited. Moreover, the relative interconnectedness of individual insurers varies substantially from period to period. This might point to changes in business models. Nevertheless, strongly varying interconnectedness over time could also show that the measure was not able to identify those insurers that are in general more connected to the banking sector. It seems worth analyzing the reasons for varying interconnectedness among insurance firms based on another measure of interconnectedness. As pointed out in *Section 5.1.1*, several authors criticize measures based on Granger causality because they claim that this measure does not only show spillovers but also common factors that influences both firms. Therefore, tests that are not based on Granger causality could be used to evaluate whether similar results to this thesis are obtained. To sum up, there are several points that leave room for further research.

8 Conclusion

This thesis presented an insight into the development of the European insurance sector and its interconnectedness with European banks. While traditional insurers differ from banks in many aspects, recently the insurance sector has become more similar to the banking sector. The insurance sector is not regarded as important for systemic risk as the banking sector. However, the recent financial crisis has led to increased interest in systemic risk in the insurance sectors and the implications of increasing interconnectedness for this risk. This thesis measured stock return spillovers between 30 insurers and 30 banks and investigated which channels could transmit shocks between the two sectors.

First, regarding the development of connections between the banking and the insurance sector, it was found that interconnectedness peaked during the financial crisis from 2007 to 2009. Connections were also high during the sovereign debt crisis between 2010 and 2012. Moreover, the influence of banks on insurers has increased since 2007. Second, several channels that have the potential to increase interconnectedness were identified. Direct and indirect spillovers could stem from traditional or non-traditional insurance activities. Some of the results were unexpected. Insurers that are parts of conglomerates did not show significantly higher numbers of connections. With regard to the traditional investment portfolio, it seems that higher investment in government bonds makes spillovers between the two sectors less likely despite the sovereign debt crisis. Turning to non-traditional insurance activities, derivative assets designated to hedge accounting were found to correlate with connections but the sign of the correlation coefficient changes over the periods. However, during the crisis, a higher proportion of derivative designated to hedge accounting was correlated with lower interconnectedness. The results with regard to unit-linked products and non-policyholder funding are more conclusive. There is some evidence that these items correlate with increased interconnection. To sum up, although significant results are limited there are some findings that point to the importance of non-traditional products for the interconnectedness of the banking and insurance sector. However, there is no significant correlation that remains over all periods. Even though the empirical part of this thesis lead only to limited results, several developments in the insurance sector presented in this thesis have the potential to create interconnectedness and to increase it further in the coming years.

Increased interconnectedness between banks and insurers has important implications for systemic risk in the whole financial sector. First, the banking sector's increased influence on the insurance sector could threaten the stability of the insurance sector. Non-traditional products such as some unit-linked products could, in theory, make insurance runs possible and

reliance on non-policyholder funding could mean that a crisis in the banking sector quickly spills over to the insurance sector. Although some authors argue that a crisis that hits the insurance sector is unlikely to have severe consequences for the real economy, recent developments might change this assumption. Especially, if the role of insurers becomes more important as banks are withdrawing from financing some parts of the economy, disintermediation of insurers might hit the real economy. On the other hand, some findings indicated that insurers could themselves cause spillovers to the banking sector. If an insurance crisis has the potential to get banks into difficulties, an insurance crisis could indeed lead to negative consequences for the real economy. Currently, the low interest environment is seen as threat for insurers, especially in the life sector. Increased linkages between insurers and banks mean that weaknesses in the insurance sector due to these developments could cause problems to banks. Spillovers from the insurance sector would hit banks in addition to their own problems due to the low interest environments.

The potential implications of increased interconnectedness make the consideration of unintended consequences of banking and insurance regulation even more important. The combined effect of Solvency II and Basel III might lead to even stronger interlinkages of the banking and insurance sector. Investment in government bonds was found to have a negative effect on risk spillovers in the empirical part. Nevertheless, details on the issuing governments were not available and thus, the quality of government bonds was not observable. Low interest environment might lead insurers to invest in riskier government bonds that have a higher yield (Düll, König and Ohls 2015). It seems likely that a further increase of insurers' investment in government bonds due to favorable capital charges will lead to an increase of interconnections. Finally, some non-traditional insurance products with bank-like features were found to increase interconnectedness. With regard to regulation, this points to the importance of considering the features of a specific insurance activity instead of the nominal sector the firm is active in (Eling and Pankoke 2014). If an insurer's business model starts to resemble that of banks but it is regulated by a different framework, regulatory arbitrage and spillovers become very likely. The development of new business models in the insurance sector should be closely monitored to avoid an increase of interconnectedness and systemic risk.

9 Literature

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Appendix – STATA Commands

Daily returns (Data Source Compustat Global via WRDS):

```
gen adjp=(prccd/ajexdi)*trfd
gen logadjp=ln(adjp)
tsset gvkey datadate
by gvkey: gen ret=logadjp-logadjp[_n-1]
egen group=group(gvkey)
```

Monthly Returns (Data Source Datastream):

```
egen group=group(name)
gen logRI=ln(RI)
by group: gen ret=logRI-logRI[_n-1]
```

Preparation:

```
by group: gen n=_n
tsset group n
```

Test ARCH effects in data:

```
forvalues id = 1/60 {
quietly reg ret if group==`id'
quietly estat archlm, lags(2)
matrix Pvalue_n[`id', 1] = r(p)
}
```

Filtering out heteroscedasticity (Following Billio et al. 2012):

```
gen garch_n
forvalues id = 1/60 {
arch ret if group==`id', arch(1) garch(1)
predict garch, variance
replace garch_n=garch if group==`id'
```

```

drop garch
}
gen fittedsd_n=sqrt(garch_n)
gen corret=ret/fittedsd_n

```

Reshape data:

```

reshape wide corret, i(date) j(*insert gvkey/group*)
tsset n

```

Granger causality test:

**1. VAR model with number of lags selected by AIC is set up – if AIC selects 0 lags, no VAR model is set up*

**2. STATA command for Granger causality test is run*

```

foreach j of varlist *insert firms* {
  foreach i of varlist *insert firms* {
    quietly varsoc `j' `i' if tin(*start date*,*end date*), maxlag(*number of lags*)
    matrix A = r(stats)
    svmat A, name(col)
    egen minh = min(AIC)
    gen optimal_lag = lag if minh == AIC
    summ optimal_lag
    local t = r(mean)
    gen `j'`i'=`t'
    if `t' > 0 {
      quietly var `j' `i' if tin(*start date*,*end date*), lags(1/`t')
      vargranger
      drop lag LL LR df p FPE AIC HQIC SBIC minh optimal_lag
    }
    else {
      drop lag LL LR df p FPE AIC HQIC SBIC minh optimal_lag
    }
  }
}

```

VAR models – check for stability and LM test for residual autocorrelation:

```
foreach j of varlist *insert firms* {  
  foreach i of varlist *insert firms* {  
    quietly varsoc `j' `i' if tin(*start date*, *end date*), maxlag(*number of lags*)  
    matrix A = r(stats)  
    svmat A, name(col)  
    egen minh = min(AIC)  
    gen optimal_lag = lag if minh == AIC  
    summ optimal_lag  
    local t = r(mean)  
    gen `j'`i'=`t'  
    if `t' > 0 {  
      var `j' `i' if tin(*start date*, *end date*), lags(1/`t')  
      varlmar  
      varstable  
      drop lag LL LR df p FPE AIC HQIC SBIC minh optimal_lag  
    }  
    else {  
      drop lag LL LR df p FPE AIC HQIC SBIC minh optimal_lag  
    }  
  }  
}
```

Test for unit root:

```
forvalues id = 1/60 {  
  dfuller ret if group==`id', lags(6)  
  matrix Pvalue_n[`id', 1] = r(p)  
}
```

Kruskal-Wallis test:

```
foreach j of varlist in_os out_os {
```

```
kwallis `j' if period==*insert period*, by(*insert category*)  
}
```

Spearman (Source blance sheet items SNL Finance):

```
spearman *insert items* if period==*insert period*, pw star(0.05) stats(rho p)
```

Abstract (English)

The financial crisis of 2008 increased attention to systemic risk in the insurance sector. In this context, some studies find increased interlinkages between banking and insurance firms. This seems surprising as insurers differ from banks in many aspects. However, the importance of conglomerates in Europe, similar investment portfolios and insurers' engagement in bank-like activities make spillovers from and to banks more likely. By applying a measure of connectedness based on Billio et al. (2012) to stock returns of 60 European banks and insurers, this thesis finds increased spillovers from banks to insurers, especially during crisis periods. However, the empirical analysis of possible reasons for varying interconnectedness among individual insurers brought inconclusive results. Understanding how linkages between banks and insurers are established is important because more linkages mean that a crisis could spread more widely. Moreover, if regulators ignore strong ties between the two sectors, regulation might have unintended consequences.

Abstract (German)

Die Finanzkrise von 2008 führte zu erhöhter Aufmerksamkeit für systemische Risiken im Versicherungssektor. In diesem Zusammenhang finden einige akademische Studien erhöhte Verflechtungen zwischen Banken und Versicherern. Das scheint überraschend, da Banken und Versicherer sehr unterschiedliche Geschäftsmodelle verfolgen. Jedoch erhöhen die Bedeutung von Finanzkonglomeraten in Europa, ähnliche Anlageklassen und Versicherungsprodukte, die denen von Banken ähneln, die Wahrscheinlichkeit von Risikoübertragungen zwischen den beiden Sektoren. Diese Masterarbeit wendet ein Maß zur Messung der Verflechtungen zwischen den beiden Sektoren an, das von Billio et al. (2012) entwickelt wurde. Die empirische Analyse der Aktienkurse von 60 europäischen Banken und Versicherern zeigt, dass der Einfluss der ausgewählten Banken auf die Versicherer größer zu sein scheint als umgekehrt, besonders während Krisenperioden. Allerdings brachte die Untersuchung möglicher Gründe für unterschiedlich starke Verbindungen der einzelnen Versicherer zu den Banken keine eindeutigen Ergebnisse. Es ist wichtig, die Gründe für das Entstehen von Verbindungen zwischen Banken und Versicherungssektor zu verstehen. Eine stärkere Verflechtung bedeutet, dass eine Krise einen größeren Teil des Finanzsystems treffen würde. Außerdem, kann ein Ignorieren von Verflechtung dazu führen, dass separate Regulierung beider Bereiche unbeabsichtigte Konsequenzen hat.